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ESSAYS ON INTERNATIONAL MACRO-FINANCE

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ABSTRACT

The first chapter establishes cross-currency differences in risk-free interest rates as a key determinant of the cost of capital at the firm level. I introduce a new security-level data set of primary market prices of corporate bond issuance and find that violations of uncovered interest rate parity (UIP) directly pass through to firm borrowing costs. As a result, firms that issue debt in currencies with high risk-free interest rates face higher effective funding costs, and, consistent with this finding, firms in countries with higher interest rates have a higher return on assets (ROA). When local currency risk-free interest rates are relatively high, firms are more likely to issue bonds in foreign currency, and when they do so, they appear to be more insulated from the local interest rate environment. This suggests that firms use foreign currency bonds as a way to alleviate domestic financial constraints.

The second chapter examines the relationship of international portfolio holdings and asset returns. When foreigners own fewer assets in a particular country, currency returns, interest rates and stock returns are all higher. This finding establishes a connection between two major puzzles in the literature, the carry trade and portfolio home bias, that have mostly been studied in isolation. I develop an international asset pricing model with agency frictions that matches the patterns documented in the data. The underlying mechanism suggests a new fundamental explanation for the existence of the carry trade, rooted in limited financial

integration, and highlights a new perspective on gross cross-border asset holdings.

The third chapter addresses the optimal structure of bank recapitalization policy when sovereign debt is risky. I combine a classic sovereign default model with private sector financial frictions, which generate fully endogenous and time-varying default costs. When the sovereign lacks commitment, I find that the impact of bank recapitalization on sovereign default risk follows a Laffer curve: Public capital infusions can decrease sovereign spreads when domestic banks are weak, even when transfers are fully financed by external borrowing. At the same time, if transfers are excessively large, recapitalization increases sovereign credit risk.

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List of Abbreviations

CoCo	....	Contingent Convertible
EM	....	Emerging Markets
FC	....	Foreign Currency
HML	....	High-minus-Low investment factor
INV	....	Investable share investment factor
LC	....	Local Currency
ROA	....	Return on Assets
RoW	....	Rest of World (ex-US)
UIP	....	Uncovered Interest Parity
US	....	United States

CHAPTER ONE

UIP Violations and the Cost of Capital: Firm-level Evidence *

Julian Richers †

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Abstract

This paper establishes cross-currency differences in risk-free interest rates as a key determinant of the cost of capital at the firm level. I introduce a new security-level data set of primary market prices of corporate bond issuance and find that violations of uncovered interest rate parity (UIP) directly pass through to firm borrowing costs. As a result, firms that issue debt in currencies with high risk-free interest rates face higher effective funding costs, and, consistent with this finding, firms in countries with higher interest rates have a higher return on assets (ROA). When local currency risk-free interest rates are relatively high, firms are more likely to issue bonds in foreign currency, and when they do so, they appear to be more insulated from the local interest rate environment. This suggests that firms use foreign currency bonds as a way to alleviate domestic financial constraints. In contrast to the role of UIP violations, differences in sovereign risk and violations of covered interest rate parity (CIP) do not exhibit a statistically significant relationship with firm borrowing costs.

1 Introduction

Over the last three decades, private-sector firms have rapidly increased their dependence on cross-border financing. From 1990 to 2019, the total outstanding amount of international corporate debt securities grew from \$1.1 trillion to \$22 trillion, a ten-fold increase in real terms.[1] In light of this dramatic increase, a growing body of literature has studied corporate cross-border financing decisions, with an emphasis on the volume of capital flows.[2] However, less is known about the prices at which international financial markets allocate capital across firms and countries.

This paper introduces a novel, security-level data set of borrowing costs on \$25 trillion in corporate bond issuance to demonstrate that firms' cost of capital varies substantially and systematically with currency denomination. In particular, I establish a direct link between (i) cross-currency differences in risk-free interest rates and violations of uncovered interest rate parity (UIP), and (ii) corporate bond borrowing costs and firms' return on assets (ROA). Violations of UIP and the existence of the currency carry trade are major stylized facts in international finance. A large literature documents that a simple strategy of lending in high-interest rate currencies and simultaneously borrowing in low-interest rate ones is highly profitable.[3] I show that this phenomenon, which has almost exclusively been studied in currency derivative markets, extends to corporate bond markets and is strongly related to real outcomes at the firm level.

As a result, this paper shows that UIP violations are of first-order importance for our understanding of firms and the allocation of capital across countries. Risk-free interest rate differentials, commonly measured in currency derivative markets as forward premia, pass through almost one-for-one to corporate bond yields. For example, I find that corporate bonds denominated in Japanese yen have substantially lower yields than bonds denominated in Australian dollars, in line with large differences in risk-free interest rates between the two currencies. Importantly, these differences are not due to firm credit risk, as they also extend to bonds issued in different currencies by the same firm. As nominal exchange rates of low-interest rate currencies do not appreciate enough to offset differences in firm borrowing costs, UIP violations extend to corporate bond markets and effective corporate borrowing costs differ substantially by currency. In contrast, I do not find statistical evidence for similar effects due to sovereign risk or violations of covered interest rate parity (CIP).

[1] BIS debt securities statistics
[2] Gozzi et al. (2015), Avdjiev et al. (2017), Celik et al. (2019), Maggiori et al. (2019)
[3] Fama (1984), Lewis (1995), Engel (1996, 2014)

Moving from individual bonds to the underlying firms, I find that differences in risk-free rates are also closely related to variation in firm capital stocks. Firms in a country with high local currency forward premia have higher output to assets ratios than observationally identical firms in a country with low risk-free interest rates, as measured by firm-level ROA. This is consistenet with the view that higher cost of borrowing translates into higher cost of capital for the whole firm. Lastly, I provide a detailed look at firm issuance behavior in global corporate bond markets. Firms in countries with high local currency risk-free rates are more likely to issue foreign currency bonds and I find that firms that do so appear to be more insulated from their domestic interest rate environment. Even among firms with similar characteristics, foreign-currency issuers have ROAs that are less closely aligned with local risk-free rates than firms that only issue bonds in domestic currency.

At the heart of this research effort is the introduction of a novel data set of corporate debt securities. Previous studies of cross-border firm financing have focused on volumes but have paid much less attention to pricing. My dataset, based on the proprietary Bloomberg Back Office universe, provides detailed primary market pricing information and bond characteristics for $ 25 trillion of corporate bond issuance. The data covers all bonds issued by non-financial corporations from 1995 to 2019, as captured in Bloomberg. While Bloomberg is a standard data provider for financial markets research, this particular data set is new to the literature because it originates from the system's underlying infrastructure, Bloomberg Back Office, which requires a separate subscription, at considerable cost, and is commonly only used by large financial institutions.

This paper makes three main contributions. First, I document a strong empirical relationship between differences in risk-free rates and corporate bond yields. The standard textbook approach defines the yield of a corporate bond security as the combination of two components: the risk-free rate and a residual, commonly referred to as the credit spread. Hence, when risk-free rates differ across currencies, one may expect that corporate bond yields issued in the repective currencies reflect this difference, which would mean that UIP violations directly pass through to firm borrowing costs. To document that this relationship holds in the data, I regress the corporate bond yield differential (i.e., the difference between the corporate bond yield, denominated in a foreign currency, and the duration-matched US risk-free interest rate) on the forward premium, which measures differences in risk-free rates between the bond's currency of denomination and the US dollar. These regressions consistently estimate a coefficient that is close to one and robust to controls for industry effects and bond maturity structure. In additional regressions, I control for a broad set of firm variables to ensure that the difference in bond yields can truly be attributed to variation in the risk-free rate component of corporate bond yields rather than to other firm characteristics. To exclude selection effects, I make use of a special feature of international bond markets and examine the yields of bonds issued by multi-currency issuers, i.e. firms that issue bonds in multiple currencies simultaneously.

Even within the same firm at the same time, bond yields vary substantially with risk-free interest rate differentials between the underlying issuance currencies. To show this empirically, I add a firm-year fixed effect to the original regression. This absorbs all variation at the firm level and as a result, the pass-through coefficient is solely estimated based on variation in bond yields within an individual firm. The underlying identifying assumption is that at a given point in time, all bonds issued by a firm carry the same default risk. This assumption is reasonable since corporate bond contracts commonly include cross-default or "pari passu" clauses.[4] This new, tightly identified regression produces a pass-through coefficient for risk-free rate differentials that is still very close to one. This indicates that selection on unobservables is not driving the earlier results.[5]

In contrast to my earlier findings, other prominent features of international financial markets, namely sovereign risk and violations of covered interest rate parity (CIP), do not appear to be statistically related to firm borrowing costs in primary bond markets after I account for differences in risk-free rates. A growing literature argues that sovereign default risk has large effects on firm borrowing costs (Bocola, 2016). However, once forward premia are accounted for, the effect of sovereign risk, measured by credit default swap contracts (CDS), on corporate bond yields is statistically indistinguishable from zero. A similar observation follows from the inclusion of CIP violations in the bond-level regressions. CIP violations describe arbitrage opportunities where interbank interest rate differentials between two currencies diverge from forward premia in derivative markets (Du et al. 2018). In primary markets, and after controlling for forward premia, the relationship between corporate bond borrowing costs and CIP violations is also statistically insignificant.

Because of the pass-through of risk-free interest rate differentials to corporate bond yields, firms face very different funding costs depending on the currency denomination of their debts. Differences in bond yields persist even after taking into account changes in the nominal exchange rate of the issuance currency. As a result, bonds issued in currencies with higher risk-free interest rates also

[4] Li et al. (2015), Liao (2019)

[5] The results are unchanged when I use firm-month fixed effects, which forces the regression to identify pass-through using only bonds issued by the same firm in a very narrow time window. In additional robustness checks, I find that other bond characteristics, such as the market of issuance or bond seniority, also do not affect my results.

have higher dollar cash flows, which means that they are more costly for the issuer. This finding provides direct evidence that violations of UIP extend to corporate bond markets and that currency denomination is a key determinant of firm borrowing costs.

Secondly, I show that the same risk-free interest rate differentials are strongly related to variations in firm return on assets (ROA). While there are strong effects of risk-free rate differentials on firm borrowing costs, corporate bonds make up only a fraction of total firm financing. Hence, I separately establish a relationship between UIP violations and firm-level cost of capital that takes into account a broader set of funding sources. A simple model of firm capital choice predicts that firms in countries with a higher risk-free interest rate will have higher required rates of return, resulting in higher output-capital ratios. I proxy for this ratio with firm-level return on assets (ROA), calculated as an average over the five years after a firm borrows in corporate bond markets. Then I regress firm ROA on the firm's local currency forward premium. Even with a broad set of firm and industry-level controls, I find a strongly positive relationship between local currency risk-free rates and firm ROA, which predicts that a firm in an economy with high currency returns, like Australia, will have a higher output-capital ratio, i.e. a lower capital stock for a given amount of output, than a similar firm in a country with low currency returns, like Japan.

Since differences in risk-free interest rates between countries are large and persistent,[6] this result uncovers systematic variation in firm ROA, and hence in firms' capital stocks. Heterogeneity in the distribution of capital across countries has been a major topic of research in international macro, also referred to as the allocation puzzle. Beyond the previously proposed factors, such as variation in property rights (Hall and Jones, 1997), taxation rates (Jorgenson, 1996), or the capital share of output (Karabarbounis and Neiman, 2014), my findings point to differences in risk-free interest rates between currencies as an important potential driver, even among developed economies. A simple example highlights the economic significance of this relationship. Over the last 20 years, risk-free interest rates have been 4.4 percent higher in Australia than in Japan. The estimated relationship suggests that the ROA of an Australian firm will, on average, be close to two percentage points higher than the ROA of an observationally identical Japanese firm (measured in common units). This difference accounts for about a third of the long-run difference in average firm ROA between Japan (9 percent) and Australia (15 percent).

Lastly, this paper provides new micro-level evidence on how firms issue bonds in multi-currency

[6] Lustig, Roussanov and Verdelhan (2011); Hassan and Mano (2019)

bond markets. These findings are important complements to those on investor portfolio holdings in Maggiori, Neiman and Schreger (2019) and provide a new dimension to earlier results based on quantities by adding data on borrowing costs. In the aggregate, non-financial firms almost exclusively issue bonds in local currency or in US dollars and I observe substantial heterogeneity in the currency composition of bond issuance at the country-level. At the firm level, size and real hedging demands from foreign sales exposure are important but not the only correlates of funding currency choice. Even after controlling for these factors, I find that firms rely more on foreign currency debt when local risk-free interest rates are high relative to the rest of the world, in particular relative to the United States. This observation suggests that firms issue foreign currency bonds to access lower financing costs available abroad, even when real hedging motives do not play a role.

Consistent with this perspective, I find some evidence that foreign-currency issuer firms are more insulated from their domestic interest rate environment than firms that only issue bonds in local currency. Given the documented relationship between local currency interest rate differentials and firm cost of capital, lower funding rates on foreign currency bonds may be related to a lower required rate of return for the firm. I again regress firm ROA on the local currency forward premium and test if foreign-currency issuer firms have a different coefficient on forward premia than local currency issuers. Accounting for the same set of stringent controls at the firm- and industry-level, I find that the alignments of firm ROA and local interest rate differentials are substantially reduced for foreign-currency issuer firms. As a result, among this subset of companies, there is less systematic dispersion in capital allocation across countries. Because a firm's ability to access foreign currency bond markets is unlikely to be exogenous, this relation is primarily a correlation and not necessarily causal. But this finding, which persists even among firms with similar size and observable real hedging motives, is consistent with the interpretation that foreign-currency issuer firms face a required rate of return that is less dependent on the local interest rate environment relative to the global one. Consistent with the interpretation that this can serve to loosen domestic financial constraints, within-firm evidence shows that becoming a foreign currency issuer is related to lower levels of firm ROA going forward.

The findings in this paper connect to several strands in the literature on international finance. Most immediately, it documents the relevance of UIP violations and the carry trade for corporate credit markets and firm real outcomes. While a number of papers show that macroeconomic factors are represented in the cross-section of currency returns (Lustig and Verdelhan, 2007; Della Corte et al. 2016; Colacito et al. 2019; Lustig and Richmond, 2019), this paper is the first to connect risk-free rate differentials and UIP violations to outcomes at the corporate bond and firm level.

In relation to the large literature on UIP violations, my findings are also relevant to a growing list of papers that study fundamental risk-based explanations of UIP violations.[7] In these papers, differences in the stochastic properties of exchange rates can generate cross-country variation in risk-free interest rates and currency returns. Countries with a more pro-cyclical exchange rate are a worse hedge from the perspective of a global investor and hence need to have higher interest rates and pay higher currency returns, on average. The underlying mechanism, shared among the different papers in this literature, has immediate implications for capital accumulation (Hassan, Mertens and Zhang; 2016). Countries with counter-cyclical exchange rates and low interest rates accumulate more capital because of the implicit hedge value of local assets.[8] My findings on the connection between firm ROA and currency risk-free rate differentials provide direct, micro-level evidence consistent with the predictions of this set of models.

The results in this paper also point to a connection to the literature on global capital allocation and development. Starting with Lucas (1990) and expanded by Gourinchas and Jeanne (2006, 2013), this line of research documents that global capital flows are at odds with the predictions of the standard neoclassical growth model. In the baseline model, low capital stocks in one country imply high returns, which should attract capital inflows from abroad. In the data, however, we observe very little flow of capital from countries with high capital stocks to those with low capital stocks. This paper also documents systematic dispersion in firm ROA at the country-level, even among firms that have access to corporate bond markets, and shows that this dispersion is aligned with long-lasting differences in risk-free interest rates. This points to a connection between firm capital stocks and different levels of required rates of return that are not matched in models with a single global risk-free interest rate.[9]

A growing literature studies the role of international financial markets and foreign currency-denominated debt for corporate borrowers (Baskaya et al., 2019; Bräuning and Ivashina, 2019; Eren and Malamud, 2019). These papers are based on the assumption that foreign currency debt provides cheaper funding rates for firms, motivating them to take on exchange rate exposure. Hence, they

[7]The list of papers include Hassan, (2013), Farhi and Gabaix (2015), Ready, Roussanov and Ward (2015), Maggiori (2019), and Richmond (2019).

[8]In these models, this is limited to firms in the non-traded sector.

[9]In this way, this paper also connects to the literature on capital misallocation at the firm level (Restuccia and Rogerson, 2008; Hsieh and Klenow, 2009)

implicitly assume that risk-free interest rate differentials pass through to individual firms (Bruno and Shin, 2017; Gopinath and Stein, 2018; Salomao and Varela, 2019). This paper is the first to provide explicit evidence for this assumption and and to estimate a pass-through coefficient in international bond markets.

In this context, the finding that foreign-currency issuer firms exhibit lower sensitivity to local risk-free rates is consistent with recent work that studies real effects of foreign currency corporate debt. Salomao and Varela (2019) develop a model of firm funding currency choice and show that, in an emerging economy, firms with access to foreign currency funding increase capital stocks more rapidly than others. The results in this paper, predominantly based on firms in advanced economies with deep financial markets, are consistent with an application of their model to a broader set of firms.[10] My findings on foreign-currency issuer firms also points to a connection between my paper and Maggiori, Neiman and Schreger (2019), who show that investors have a strong bias towards holding assets denominated in their home currency or the US dollar. My findings are consistent with the idea that investor segmentation along currency denomination may have real effects on the international allocation of capital. In thematically related work, Liao (2019) studies the interaction of CIP violations and corporate credit spreads in secondary market pricing, while I consider the role of UIP violations in overall firm funding costs in primary markets.

The paper is structured as follows. Section 2 discusses the data set and its construction. Section 3 studies the connection between currency interest rate differentials and firm bond borrowing rates, while section 4 documents that UIP violations are also closely related to firm-level variation in ROA. Section 5 discusses variation in the currency composition of corporate bond issuance and the distinct relationship between firm real outcomes and domestic currency risk-free rate differentials for foreign-currency issuers. Section 6 concludes.

2 Data

This paper is based on a newly compiled data set that combines three separate databases of corporate bond securities, firm fundamentals, and currency market instruments. I discuss each in turn below.

[10] 90 % of the firm-level observations in my sample are related to firms in developed economies.

2.1 Corporate Bonds

The main empirical innovation of this paper is the introduction of a novel data set of primary corporate bond issuance. What sets this data set apart from the existing literature on international corporate financing is the availability of primary market prices, which represent the actual cost that firms pay to raise funds in corporate bond markets.[11] My data set consists of 105,000 individual corporate debt securities issued by 17,000 firm entities and covers $25 trillion of gross bond issuance from 1995 to 2019. These observations represent all corporate bond securities issued by non-financial, private-sector firms, as far as they are captured in the Bloomberg data universe. While Bloomberg is a standard source for research on financial markets, this particular data set is new to the literature as it requires a separate, costly subscription to the metadata underlying the Bloomberg system (Bloomberg Back Office). Bloomberg Back Office is generally only accessed by financial firms, where, among other uses, it is often a key input in security master lists that are important for portfolio monitoring and risk modeling. I gain access to this data through a large financial institution.

While Bloomberg Back Office contains more than 500,000 individual securities that are widely defined as corporate debt securities, I focus on the subset of corporate bonds issued by private sector non-financial firms. I exclude any bonds whose sector description indicates the financial industry or the government sector. To this end, I consider both the immediate issuers' designation as well as that of the ultimate parent companies, which is also identified by Bloomberg. Also, I exclude commercial paper and other short-term instruments with a time to maturity below one year but include private placements.

For each bond, I have a detailed set of attributes available, such as total amount issued, currency denomination, maturity date, coupon size, type and frequency, embedded options, bond seniority, and the market of issuance. I also observe the name, ticker, and country of origin for each issuer firm and, if applicable, any parent firms thereof, as identified by Bloomberg. This is an important piece of information since firms frequently use subsidiaries domiciled in different countries to issue securities (BIS, 2016; Copola et al. 2019).[12]

[11] Most firms issue bonds infrequently and the process is connected with long lead-up times, all of which may lead to secondary market prices being an inexact measure of actual firm financing costs. The issuance process generally includes a pre-launch stage, which consists of legal preparation and negotiations with advising investment banks and a separate launch or "road show" period, during which the firm and the representing banks drum up investor interest. The advising investment banks ("book runners") commonly allocate shares of the issuance to specific investors rather than releasing all of it into open markets.

[12] For example, the automaker BMW issues bonds in different currencies through different direct subsidiaries that are located in the respective countries: BMW Finance N.V. issues euro-denominated bonds and is domiciled in the Netherlands, while BMW US Capital LLC issues US dollar-denominated debt, and is domiciled in the US.

Most relevant for my purposes, the available information on the bond coupon structure and the issuance price allow me to calculate the yield-to-maturity on all fixed-coupon and zero-coupon bonds in my sample. I also convert each bond's issuance amount to US dollars using the spot exchange rate of the issuance currency at the time of issuance.[13]

For external validity, I compare the total volume of gross bond issuance in my data set against volume calculations by the OECD (Celik et al. 2019), which also looks explicitly at non-financial firm issuers. Gross issuance in my data set is at least as large as what they document, based on SDC Platinum data, on a year-by-year basis. The Bloomberg data set also provides additional historical data back to the pre-2000 period (see Figure 1-A1 in the Appendix). As a result, my data set provides a comprehensive picture of global corporate bond issuance by non-financial firms, which extends beyond the data universe traditionally used in the literature.

In the following, I use the data set of individual corporate bonds in two ways. In the bond-level analysis in Section 3, I study the explicit borrowing costs associated with each security and its connection to currency market instruments. As a result, this analysis is based on all corporate bonds with no missing pricing information and a fixed- or zero-coupon cash flow structure that is required to calculate the yield to maturity. Also, I drop all bonds with special features, such as convertible bonds, bonds with dual currency payout structure, or with inflation indexation (popular in Latin American markets). This results in a data set of 53,000 individual bond securities for which the appropriate currency market data is available, as described below. Panel A in Table 1-7 shows the summary statistics of the bond data set. The median bond has a yield-to-maturity of 4.8 percent, a time-to-maturity of seven years, and a duration of 5.7 years. The median bond raises $130 million, converted at spot exchange rates, though the distribution of bond sizes is widely dispersed and with a large right tail. In Sections 4 and 5, I aggregate up all available bonds to calculate total bond issuance volume and the underlying currency composition at the firm level, as desribed in the next section.

2.2 Firm fundamentals

For the study of firm behavior, I trace back the individual bonds to the underlying issuers. Using the Factset data universe, I match each bond ISINs to the commensurate Factset identifier, which connects to the underlying firm. This way, I can match two-thirds of the total dollar gross issuance

[13] I use the closing exchange and forward rates at month end.

volume at the bond level ($17.4 trillion). This results in 20,500 firm-year observations where I observe both firm fundamentals and primary bond issuance activity.[14]

The Factset data set provides extensive information on corporate balance sheets for public and private firms globally. Given that countries outside of the US often do not require quarterly reporting, I use balance sheet data as collected from annual reports. The variables of interest include firm total assets, sales, earnings, net income, debt, and cash holdings. I present most variables as ratios to firm assets or sales, otherwise I convert figures using the annual average exchange rate of the currency of documentation to the US dollar. I also trim the resulting variables at the one-percent level to deal with extreme outliers that are most likely due to data error. All results are robust to the inclusion of outliers. Of particular interest are data on firm international exposure, which I measure as the ratio of international sales to total sales, and international assets to total assets, where all assets and sales outside of the firm's country of origin are taken into account.

For consistency, I ascribe to each firm the ultimate parent company's country designation from Bloomberg, as previously used at the bond level. I confirm that my results are robust to using the immediate firm's country of origin as identified by Factset. The data set is quite diverse in regional exposure, with around a third of all matched firm-year issuance observations coming from the US (accounting for $8.2 trillion of total issuance). Panel B in Table 1-7 displays the summary statistics for the firm-level data set. Across all firms identified from the bond-level data, the median amount of total issuance (the sum of all bonds issued in a given year) is $430 million, again with a large right tail of very high issuance amounts.[15] Converted at spot exchange rates, the median firm has close to $9 billion worth of assets and a return on assets (ROA) of 10.5%. Median firm leverage is 34% and cash holdings are 24%. Around a quarter of all sales are sourced internationally for the median firm.[16]

[14]Factset directly links bonds to the underlying firm if issuance takes place through a wholly-owned subsidiary, as in the example of BMW's different subsidiaries used for bond issuance. To be conservative, I do not aggregate up beyond this immediate match from Factset.

[15]Large bond issues are often used to fund M&A transactions. The largest individual bond in my sample is a Verizon 30-year security with an issue amount of $15 billion, which is part of a $49 billion raise in 2013 to fund the acquisition of Vodafone's minority share in Verizon Wireless.

[16]The duration and maturity profile of bond issuance, averaged by firm, is similar to the distribution at the bond level.

2.3 Currency markets

Lastly, I collect spot and forward exchange rate data on 26 currencies, including all major developed market currencies and the main actively and freely traded emerging market currencies, for which the necessary currency market instruments are available in Bloomberg.[17] All exchange rate measures, spot and forward, are measured against the US dollar.

I follow the literature on UIP violations and calculate the forward premium in currency markets (Engel, 1996) to measure differences in risk-free interest rates. Under the assumption of covered interest rate parity (CIP), the spread between the forward and the spot exchange rate is equal to the difference in risk-free interest rates between the two currencies.[18] In the following, I define the differential between risk-free interest rate r in currency j and the US dollar as

$$r_t^j - r_t^\$ = f_t^j - s_t^j,$$

where s^j and f^j denote the log of the current level of spot and forward exchange rates of currency j to the dollar. The forward premium represents differences in *risk-free* rates, as forward contracts are free of sovereign default risk since they are struck with international broker-dealers or banks instead of national institutions. Contracts are standardly collateralized, and any counterparty risk would affect all contracts instead of varying systematically across currencies.

International investors can directly operate in currency forward markets, which are deep and highly liquid.[19] As a result, the literature on UIP violations, starting with Fama (1984), has almost exclusively studied this set of instruments. Across currencies, the forward premium provides a standardized measure of interest rate differentials, which is of particular importance for emerging market currencies, where interbank markets may be less accessible or contaminated with default risk. Since currency forwards are less liquid for longer time horizons, I rely on cross-currency swaps

[17] Since access to local capital markets is highly restricted and currency markets are actively managed, this means that I do not include China in my analysis. Chinese corporate bond markets have grown dramatically in recent years, but the lack of currency convertibility for both firms and investors make cross-currency comparisons of borrowing cost not immediately comparable.

[18] While CIP has historically held across frequencies and maturities in currency markets, Du et al. (2018) document sizeable deviations during the financial crisis and smaller ones in the time since. I control for these deviations in the bond-level analysis and find that they do not appear to have a significant effect on firm borrowing costs.

[19] The latest BIS Triennial Central Bank Survey puts total daily turnover in currency markets at $6 trillion US dollars in 2019. Currency forwards and swaps make up more than 65% of daily turnover. While most of the volume is concentrated in maturities of one year or less, currency swaps and forwards with maturities of over one year had an average daily turnover of $ 48 billion in 2016, the last available data point. For reference, the World Bank puts the total value of all stocks traded globally at $ 77 trillion for the same year, which comes out to $ 300 billion of daily turnover, assuming 252 trading days.

from interbank markets to calculate the forward premium for risk-free differentials with maturities of longer than a year (Du and Schreger, 2016).[20] I obtain all relevant currency instruments from Bloomberg.

In line with the data on forward points and currency swaps, I measure the US risk-free interest rate with US dollar interbank interest rate swaps (IRS) at the same maturity points.[21] In the data, the interbank swap rate is generally close to the interest rate on a comparable government bond. I also add data on violations of CIP, measured using the cross-currency basis.

Lastly, I also add data on sovereign default swaps (CDS) from Bloomberg. These measure the cost of insurance against default on the US dollar-denominated sovereign bond of a given country. To make sovereign spreads directly comparable to differentials in risk-free interest rates between currencies and the US dollar, I compute a similar differential between each country's sovereign CDS and the CDS on US government bonds.

3 Risk-free interest rate differentials and corporate bond yields

In this section, I show that differences in risk-free interest rates across currencies pass through to corporate borrowing costs in bond markets. Recent work has documented that cross-country differences in risk-free rates are large and persistent and that nominal exchange rates do not move enough to erase these differences, leading to violations of UIP (Hassan and Mano, 2019). Hence, if risk-free interest rate differentials pass through to corporate bond yields, then corporate bonds will also be affected by UIP violations. As a result, firms face different financing costs based on the denomination of their bonds, a new observation since UIP violations have historically only been documented in government bond and currency derivatives markets.

[20] I calculate risk-free interest rate differentials using forward and cross-currency swap contracts at the 1, 2, 3, 5, 7, and 10-year maturity points and linearly interpolate for the intermittent years, as in Liao (2019).

[21] I use the interest rate on the fixed leg of a fixed-for-floating interest rate swap, in which market participants agree to swap floating interest payments at the current LIBOR rate against fixed-rate payments for the duration of the contract.

3.1 Linking risk-free interest rates to corporate bond yields

How do risk-free rates relate to corporate bond yields? In a standard asset pricing model, we can write the price of a one-period risky (corporate) bond, issued by firm i in currency j as

$$P^j_{i,t} = \mathbb{E}\left(M^j_{t+1}(1 - D_{i,t+1})\right), \tag{1}$$

where M^j denotes the pricing kernel in currency j (Backus, Foresi and Telmer, 2001) and D_i describes the loss on default. Assuming risk neutrality for parsimony, and using the standard property of the pricing kernel that

$$\mathbb{E}\left(M^j_{t+1}\right) R^j_t = 1, \tag{2}$$

where R^j denotes the risk-free interest rate in currency j, we can re-write this expression in logs. Approximately, this gives

$$y^j_{i,t} = r^j_{t+1} + d_{i,t+1}, \tag{3}$$

where y^j_i denotes the yield on the bond issued by firm i in currency j and d_i is defined to represent the residual or the expected loss from default, which is equivalent to the credit spread under risk-neutrality. [22] As a result, we observe that the yield on a corporate bond represents the combination of a credit spread (or residual) and a risk-free rate, which depends on the currency of bond denomination. Hence, if risk-free interest rates differ across currencies, bond yields will vary accordingly. Subtracting the US dollar risk-free rate on both sides, we can uncover a relationship between corporate bond yields and the risk-free interest rate differential between the dollar and the currency of bond denomination:

$$y^j_{i,t} - r^\$_t = (r^j_t - r^\$_t) + d_{i,t+1}. \tag{4}$$

This equation shows that differences in risk-free interest rates, which can be approximated with forward premia in currency markets, should directly pass through to corporate bond yields. In this section, I test if this relationship is reflected in the data while controlling for variation in the credit spread residual. Because of the large literature that documents violations of uncovered interest rate

[22] Under the assumption that credit risk for a given firm is independent of bond currency denomination, d only depends on i, not j. As I discuss below, this assumption is based on the observation that corporate bond contracts commonly include cross-default clauses, under which default is indiscriminate. Without risk neutrality, d_i would also include potential covariance terms between the pricing kernel and firm default, which may differ by by currency denomination. I discuss this special case in appendix A2.

parity in risk-free interest rates, if these differentials pass through to corporate bond yields, this implies that firms will differ in their cost of financing based on the currency denomination of their bonds.

Before moving to the regression analysis, I inspect the data visually. As a particularly prominent example, Figure 1-1 shows a boxplot of the yield-to-maturity on all corporate bonds issued in Japanese yen (JPY) on the left-hand side and of those issued in Australian dollar (AUD) on the right-hand side. For each year covered in my sample, the graph shows the interquartile range (IQR) of yields with boxes, while the whiskers capture the minimum and maximum values observed. The graph shows some variation in corporate bond yields within currency denomination but differences in bond yields across denominations are substantially larger. While corporate bond yields can vary for a whole range of reasons, in particular as they pertain to differences in credit risk across firms, the most obvious explanation for the cross-currency variation in bond yields is the difference in risk-free rates between the yen and the Australian dollar. The thick line in each graph shows the 5-year risk-free rate in each currency.[23] Since risk-free rates are substantially higher in Australia than in Japan, corporate bond yields in Australian dollars are systematically and meaningfully higher. As a result, the graph crystalizes the first key observation of this paper, which I document more rigorously in a regression setting below.

A less immediate but important observation in the graph is that, at least on some rare occasions, we observe corporate bond yields that are below the 5-year risk-free rate. This, however, does not indicate that firms can borrow at rates that are lower than the respective issuance currency's risk-free rate. Instead, it reflects that firms issue bonds with a wide range of maturities. While the 5-year risk-free interest rate is an appropriate point of comparison for the median bond in the sample, which has a duration of 5.7 years, it is likely to be a less accurate match for securities that have noticeably shorter or longer maturities. Furthermore, corporate bonds also exhibit substantial heterogeneity in their payout structure. While a small set of bonds only repays the bond's face value at the time of maturity (zero-coupon bonds), most bonds have regular coupon payments scheduled over the life of the bond. The cash flow properties of most corporate bonds hence stand in contrast to those of the standard measures of risk-free interest rates and forward premia, which are generally zero-coupon instruments.

[23] Consistent with the construction of forward premia, I measure the risk-free rate from the fixed-rate leg of a fixed-to-floating interbank interest rate swap. In the data, these rates closely follow the respective government bond benchmark rate.

To jointly account for these differences in the regression analysis below, and in order to make corporate bonds comparable across characteristics and currencies, I match each security to the respective risk-free rate measures based on each bond's duration. The duration of a bond represents the average time to repayment, based on the timing of all cash flows. As a result, a corporate bond with a high coupon will have a shorter duration than maturity.[24] Since duration is equal to the time to maturity for a zero-coupon asset, a corporate bond with a five-year duration will be matched to the five-year forward premium, for example.[25]

3.2 Regression analysis

Building on this foundation, I can now test for the link between risk-free interest rate differentials and corporate bond yields, while controlling for alternative explanatory factors. The standard regression is specified as

$$y_{i,t}^{j,d} - r_t^{\$,d} = \beta(r_t^{j,d} - r_t^{\$,d}) + X'_{i,t}\gamma_t + \theta_t^{industry} + \omega_{l,t}^{maturity} + \epsilon_{i,t}, \tag{5}$$

where $y_{i,t}^{j,d}$ denotes the yield on a corporate bond denominated in currency j and with duration d. $r^{j,d}$ refers to the risk-free rate in currency j with the matching duration d. X denotes the vector of controls at the firm level, θ captures the industry-year fixed effect, and ω denotes the maturity bucket-year fixed effects.

I use the corporate bond yield in currency j minus the duration-matched US risk-free rate as the left-hand side variable. This ensures that all bonds are compared to a common baseline, similar to the perspective of a US investor. On the right-hand side, I include the forward premium, i.e. the risk-free rate differential between the bond's currency of denomination j and the US dollar. As described above, all interest rate variables, including the forward premium, are matched to the underlying corporate bond's duration d to adjust for differences in interest rate risk. In order to account for possible systematic variation of credit risk of issuer firms with bond currency denomination, I include

[24] A 7-year bond with annual coupon payments at an annualized rate of 10 percent, issued at par and with a yield-to-maturity of 10 percent, will roughly have a 5-year duration. The formula for Macaulay Duration M is $M = \frac{\sum_{t=1}^{n}\left(\frac{t \cdot C}{(1+y)^t}\right) + \frac{n \cdot V}{(1+y)^n}}{P}$, where P represents the current bond price, n denotes the total number of years (or coupon payment periods), and y is the periodic yield. C denotes the coupon payments and V the bond's maturity value.

[25] This approach follows Gilchrist and Mojon (2018), who show that this procedure delivers a close approximation of the exact cash-flow matching in Gilchrist and Zakrajsek (2012). In the appendix, I document that my empirical findings are robust to the alternative matching process, based on bond maturity (Table 1-A3).

a broad set of controls of firm characteristics and industry-year fixed effects. Lastly, in addition to duration-matching, I also account for variation in bond maturity directly in a non-parametric way by including bond maturity buckets, interacted with year-fixed effects. This controls for the possibility that there are systematic differences in bond maturity by issuance currency.[26] In addition, I separately consider the role of sovereign risk and CIP violations in Section 3.4.

The regression results are reported in Table 1-7. Unless otherwise noted, I report standard errors that are clustered at the country level.[27] The first row presents the estimates of the coefficient on the risk-free interest rate differential, $\hat{\beta}$, which can be interpreted as a pass-through coefficient. Throughout the different specifications, the coefficient is consistently estimated to be almost exactly equal to one, with a high degree of statistical significance and a low standard error, ranging between 0.05 and 0.1. This indicates that observed differences in risk-free interest rates across currencies pass through directly to corporate bond yields.

Since the yield on a corporate bond contains both risk-free interest rates as well as compensation for credit risk, it is possible that selection between currency forward premia and firm characteristics drives the estimated coefficient. This could overstate the effect of forward premia if riskier firms are more likely to issue in high-interest rate currencies. In order to account for this possibility, I consider a range of additional controls that are likely correlated with credit risk.

Column 1 shows the pass-through coefficient based on the baseline regression without industry-year fixed effects and without firm characteristics. Column 2 adds industry-time fixed effects, and Column 3 adds firm-level characteristics. These variables appear to be statistically related to the corporate credit risk residual: firm size, measured as the log of total firm assets in US dollars, is strongly negatively related to corporate bond yields, consistent with the observation that larger firms tend to be less risky. Firm leverage, on the other hand, is positively related to bond yields, in line with intuition.[28] Even after controlling for a range of variables that are conceptually closely related to the credit spread residual in corporate bonds, the estimated coefficient on the currency forward premium is stable and persistently close to one.

[26] I use separate buckets for bonds with a maturity of one to three years, three to seven years, and for maturities greater than seven.

[27] The appendix provides a broad range of alternative standard error calculations that document the robustness of my empirical results. Countries in the euro area are treated as separate clusters, but my findings are robust to treating them as one.

[28] Corporate cash holdings are positively related to bond yields, although this finding is not robust in additional specifications discussed below. Also, I do not find evidence that, after controlling for variables discussed above as well as currency forward premia, firms with more international exposure have higher borrowing costs. Table 1-A3 in the appendix further shows that the results persist in subsamples of bonds with explicitly similar duration.

I further document that these differences in bond yields directly translate into differences in effective borrowing costs at the firm level, after taking into account changes in the nominal exchange rate. Under the assumption of UIP, current differences in risk-free interest rates are offset by future shifts in the nominal exchange rate so that, ex post, total returns in common currency are equalized. I test for the failure of UIP at the firm level by calculating the effective borrowing cost of a given corporate bond. If UIP held over the life of a bond, then we would expect that the currency in which the borrowing firm makes coupon and principal payments appreciates if the respective risk-free rate is low. The currency appreciation would hence increase the effective (US dollar) repayment costs for the firm. Next, I test if differences in risk-free rates between currencies are related to differences in realized borrowing costs.

To approximate the effective borrowing costs in different currencies, I add the annualized rate of appreciation in the nominal exchange rate of the bond's currency of denomination to the US dollar over the life of the bond, so that the regression's left-hand side variable is now defined as:

$$y_{i,t}^{j,d} - r_{i,t}^{\$,d} + \Delta s_{i,t+d}^{j,d}, \tag{6}$$

where $\Delta s^{j,d}$ denotes the annualized change in the nominal exchange rate of currency j versus the US dollar from time t to $t + d$, and a positive number indicates appreciation of the local currency. Because of the frequent coupon payments of many corporate bonds, which means that firms already pay out a substantial amount of borrowing costs way before the maturity date, I calculate the change in the nominal exchange rate from the time of issuance t to the point in time in the future that represents the average weighted time of all cash flows $t+d$. I then repeat the baseline regression with this new variable on the left-hand side. If risk-free interest rate differentials were perfectly offset by nominal exchange rate shifts over the life of a bond, then the effective borrowing cost in US dollars, i.e. the corporate bond yield plus currency appreciation, should show no relation to risk-free interest rate differentials. Instead, the effective borrowing cost should be the same for all bonds, irrespective of their currency denomination.

The data strongly rejects the hypothesis that systematic exchange rate depreciation offsets differences in corporate bond yields, which would imply an estimated β coefficient of zero. While the coefficient on the forward premium is slightly smaller, the pass-through is still very high at 0.7, with a standard error between 0.13 and 0.19. Using the same regression specifications as before, I find that higher risk-free interest rate differentials are also strongly related to higher effective financing costs. The slight decrease in coefficient size may represent the tendency of high-interest rate currencies to depreciate somewhat more than low-interest rate currencies, but nowhere near what would be required by UIP. In addition, the larger standard errors also suggest that the increased volatility from including the exchange rate term may bias the estimated pass-through coefficient towards zero. In conclusion, there is ample evidence that differences in risk-free interest rates across currencies are directly related to corporate borrowing costs, both ex ante and ex post.

3.3 Within-firm evidence

Even though I control for a number of different axes of differentiation across firms, I cannot fully exclude the possibility that there are selection effects between the issuer firm and bond currency denomination. I approach this concern in two ways. First, Oster (2019) proposes a formalized test for the robustness of a coefficient to bias from selection on unobservables. I show in the Appendix (Section A1) that the pass-through coefficient passes the established critical values, which indicates robustness. A second approach, based on particular features of international corporate bond markets, provides a more direct test that also allows for a more precise estimate of the size of the pass-through coefficient.

In my data set, I observe that a subset of firms issue bonds in multiple currencies and often does so in close succession. As a concrete example, I observe that BMW issued a US dollar-denominated bond on August 14, 2018, and subsequently issued a euro-denominated bond two weeks later. Even though the bonds are similar in maturity structure and size, the yield-to-maturity is dramatically lower on the euro-denominated bond, in line with the risk-free interest rate differential between the two currencies at the time. Since it is relatively unlikely that BMW's credit risk had changed drastically over the course of two weeks, I use within-firm variation in borrowing costs to identify the pass-through of risk-free rate differentials to corporate bond yields.

Multi-currency issuer firms are not a rare aberration in bond markets. While firm-year observations with multi-currency issuance make up less than ten percent of the total number of observations in the sample, they account for close to a fourth of total gross issuance ($ 6.8 trillion). More generally, multi-currency issuers are responsible for three times as many bonds and four times as much dollar volume in a given year as the average firm.[29]

[29] Details on the relative figures are provided in the appendix in Table 1-A3.

In order to take advantage of this feature in the data, I return to the regression setting from above and add a firm-year fixed effect. As a result, the pass-through coefficient is no longer estimated across firms but instead only within firms. Since the firm-time fixed effect absorbs the average bond yield for the firm at a given time, we can directly attribute differences in bond yields to variation in currency denomination.[30]

The key identifying assumption for this regression is that, for the same firm at the same time, bond currency denomination is uncorrelated with other drivers of bond yields, and credit risk in particular. This assumption would not be valid for sovereign bonds, where selective defaults and restructurings are common and credit spreads reflect this distinction (Du and Schreger, 2016). However, it is appropriate in the case of corporate bonds since the underlying bond agreements commonly contain cross-default clauses.[31] These clauses effectively make selective default highly costly for corporate borrowers, since default on a single bond allows all lenders (including bondholders) to sue the issuer company for bankruptcy and to accelerate any outstanding debt payments.[32]

Since the firm-year fixed effect subsumes any variation at the cross-firm level, I can drop firm and industry-level controls.[33] The regression now takes the following form:

$$y_{i,t}^{j,d} - r_t^{\$,d} = \kappa_{i,t} + \beta\left(r_t^{j,d} - r_t^{\$,d}\right) + \omega_{m,t} + \epsilon_{i,t}, \tag{7}$$

where κ denotes the firm-time fixed effect and all other terms are as described above. The resulting pass-through coefficient, which is now cleanly identified and not exposed to potential selection between issuer firms and issuance currency, is presented in Table 1-7. Even with this stringent set of controls, the pass-through coefficient is still estimated to be very close to one, at 0.85 and with a standard error of 0.07. This documents that even within a single firm at the same time, bond yields can differ substantially and do so in alignment with the differences in risk-free interest rates of the underlying issuance currencies. Furthermore, the stability of the regression coefficient, which is only slightly smaller in the within-firm estimate relative to the across-firm estimate, suggests that

[30] The duration-matched US risk-free rate on the left-hand side and the maturity bucket-year fixed effects take into account differences in yields that arise from differences in bond maturities. Table 1-A3 in the appendix shows that the coefficient is stable in regressions based on subsamples of bonds with similar duration.

[31] Li et al. (2015), Liao (2019)

[32] In additional robustness checks in Table 1-A3, I further demonstrate that my results are not affected by differences in bond issuance markets, or by bond seniority, which are additional reasons why credit risk may vary across bonds issued by the same firm.

[33] This allows me to broaden my sample, since I can also include bonds for which I do not find a match in Factset, and hence do not have underlying firm data or industry classification. These sample additions do not change the estimated results.

selection effects between firms and bond denomination are not driving the overall results.

While the firm-time fixed effect absorbs all firm-level characteristics that may be related to corporate bond yields, it can most immediately be interpreted as absorbing credit risk. Since firms issue only a small number of bonds (2.2 per year on average) and do so intermittently, holding the fixed effect constant for all bonds issued by a firm in a given year allows me to compare a broad set of bonds from a larger set of issuers. However, this comes at the expense of the assumption that changes in credit risk at the firm level over the course of a year are uncorrelated with bond currency denomination. To document that this assumption is not crucial for my results, I replace firm-year with firm-month fixed effects. In turn, I lose a number of observations but gain additional precision because I only compare bonds that are issued in close proximity or even at the same time as different tranches of the same offering. Column 2 shows that this results in a more tightly estimated pass-through coefficient of 0.92, with a standard error of 0.025, which further supports the previous findings.

In addition, Columns 3 and 4 show that differences in bond yields within individual firms lead to substantially different ex post borrowing costs. Here again, I add the change in the nominal exchange rate of the issuance currency relative to the US dollar over the duration of the underlying bond in order to approximate the effective borrowing cost. The coefficient is somewhat smaller than one and less precisely estimated, with point estimates of 0.44 with a standard error of 0.25 for the regression with firm-year fixed effects and 0.62 with a standard error of 0.23 with firm-month fixed effects. Still, as a result I observe violations of UIP even within individual firms.

3.4 Sovereign risk and CIP violations

Given the important role of UIP violations on firm borrowing costs documented above, I next study if there is evidence that other prominent features of international financial markets, like sovereign risk and violations of covered interest rate parity, have similar effects.

First, a growing literature points to the role of sovereign risk in driving corporate borrowing costs. Bocola (2016) models how sovereign risk tightens financial conditions for local firms. More immediately related to the study of corporate bond markets, Almeida et al. (2016) show that sovereign downgrades can have a direct effect on firm outcomes through the sovereign ceiling effect, i.e. the policy followed by rating agencies that no private entity in a particular country can have a higher credit rating than the underlying sovereign. In my data set, I can test for the effects of sovereign risk on corporate bond borrowing costs directly. I measure sovereign risk using credit default swaps, which represent the cost of insuring a five-year sovereign bond against a default event. In order to give sovereign risk the same interpretation as currency forward premia, I calculate CDS differentials relative to the CDS on US Treasuries.

There are two different approaches to relate sovereign risk to corporate bonds. First, sovereign risk may affect the firm as a whole, for example, through the sovereign ceiling on ratings. To test this assumption, I run a cross-firm regression with the CDS differential but without firm-year fixed effects, since those would absorb any firm-level variation that may be related to sovereign risk.[34] The regression results are reported in Columns 1 and 2 in Table 1-7. After accounting for risk-free interest rate differentials, the coefficient on the sovereign CDS is small and becomes statistically indistinguishable from zero when I include a set of firm-level characteristics as controls (size, leverage, cash holdings, and international sales share). This suggests that for firms with bond market access, cross-country variation in sovereign credit risk is difficult to disentangle from firm-level developments. Second, I also test if sovereign risk has an effect at the bond-level rather than the firm-level and match the sovereign CDS differential to each bond based on currency denomination.[35] The results in columns 3 and 4, which include firm-time fixed effects, again show no statistical significance.

Given the extensive literature on the topic, it is perhaps surprising that the empirical findings are not more clear cut. Here, it is useful to consider the characteristics of firms that have bond market access. Firms in my sample tend to be large and are likely to be less dependent on bank financing. Therefore, the limited effect of sovereign risk on corporate borrowing costs is consistent with the argument in the literature that sovereign risk predominantly affects firm financial conditions through the banking sector (Perez, 2015). Firms with a higher dependence on bank financing, such as firms without bond market access, may hence be more severely affected than firms with alternative financing sources (Arellano, Bai, and Bocola, 2019).[36]

Second, I study the role of violations of covered interest rate parity (CIP) for corporate borrowing costs. As described above, I rely on forward premia to calculate cross-currency differentials in risk-free interest rates. Under the assumption of CIP, forward premia exactly capture differences in the respective interbank rates. Up until the financial crisis, this assumption was generally un-

[34] As before, I identify each firm's country of origin based on the firm's ultimate parent company.
[35] Euro-denominated bonds are matched to the German CDS differential.
[36] An important caveat here is that I only observe issuance yields. While I control for firm observables, it is technically possible that the unobservable risk profile of the issuer pool shifts in ways to offset increased sovereign risk.

controversial since CIP deviations were minuscule (Du, Tepper, and Verdelhan, 2018). However, in recent years and especially in periods of financial market stress, there has been more evidence that interbank interest rate differentials and forward premia do not always align.

Since CIP violations describe risk-free arbitrage opportunity, this observation has generated much interest. A recent paper documents that CIP deviations align with cross-currency variation in credit spreads in secondary markets (Liao, 2019). To explore the implications that these deviations may have for firm borrowing costs in primary markets, I next test for a connection between CIP violations and corporate bond yields at issuance and add the duration-matched cross-currency basis, i.e. the arbitrageable difference between forward premia and the interest rate swap differential, to the baseline regression.[37] Since the cross-currency basis applies at the currency level, I can estimate the relationship using the tightly identified within-firm regression, consistent with Liao (2019). The results are reported in Columns 5 and 6, while controlling for firm-year and firm-month fixed effects, respectively. As is observable from the estimated coefficients, the inclusion of CIP violations does not change the pass-through coefficient on the forward premium, which remains close to one. Further, CIP violations do not appear to have a significant effect on corporate borrowing costs in primary markets, at least once I account for the forward premium.

These results show that differences in risk-free rates and UIP violations appear to have a particularly important status when it comes to firm financing costs in international bond markets. This importance does not appear to be matched by other factors, which have received relatively more attention in the literature with respect to firm funding costs. This points to substantial room for further theoretical and empirical work to explore the role of UIP violations on firm behavior and outcomes.

4 UIP violations and firm cost of capital

This paper documents that firms that issue predominantly in currencies with low forward premia are likely to have a lower cost of funds raised in bond markets, all else equal. However, corporate bonds only account for a portion of firm financing, while internal funds, equity issuance, and bank loans may account for the rest. As a result, it is unclear how meaningful the variation of bond borrowing costs with risk-free interest rate differentials is for the cost of capital at the firm level. I now explore

[37] Following Du et al. (2018), the cross-currency basis is defined as $basis_t^{j,d} = (irs_t^{\$,d} - irs_t^{j,d}) - (f_t^{j,d} - s_t^{j,d})$, where $irs^{j,d}$ denotes the interbank swap rate with duration d in currency j.

to what extent risk-free interest rate differentials are related to variation in firm real outcomes.

Abstracting from default risk, in a standard model of a firm with a CRS production function and competitive markets, the firm's profit maximization problem yields the following first-order condition with respect to capital:

$$\mathbb{E}\left(\frac{Y_i}{K_i}\right) = \frac{\mathbb{E}\left(r^j\right) + \delta}{\alpha}, \tag{8}$$

where the $\mathbb{E}\left(\frac{Y_i}{K_i}\right)$ denotes firm i's expected ratio of output to capital, α denotes the capital share of output, and δ describes the depreciation rate. In turn, $\mathbb{E}\left(r^j\right)$ captures the required net rate of return on capital. As documented above, variation in risk-free interest rates across currencies pass through to the risk-free component of corporate borrowing rates in bond markets, and as a result, this suggests that the required rate of return varies with currency j, even in absence of default risk.

In consequence, the simple firm model predicts a link between differences in risk-free interest rates and firm-level outcomes. Firms that face lower risk-free interest rates, and hence lower required rates of returns, will have lower output-capital ratios. This indicates that all else equal, firms that fund themselves in currencies with higher risk-free rates will have relatively fewer assets.

To test this prediction empirically, I move the analysis from the bond level to the firm level. As described in the data section, I trace individual bond issues to the underlying issuer firms and retrieve the underlying balance sheet data. I explicitly consider firm outcomes around bond issuance events, though my results persist in panels where I include non-issuance years for the same set of firms.

At the firm balance sheet-level, I approximate the output-capital ratio, and hence the level of the firm's required rate of return, by the firm's return on assets (ROA).[38] I define firm ROA as

$$\overline{ROA}_{i,t+5} = \frac{1}{5}\sum_{n=1}^{5} \frac{EBITDA_{i,t+n}}{Assets_{i,t+n}}, \tag{9}$$

where EBITDA denotes total firm earnings before interest, taxes, depreciation, and amortization. Assets represent total firm assets. Since both figures come from the same annual reports, the contemporaneous ratio of the two is directly comparable across currencies. I calculate ROA as the

[38] In doing so, I follow the empirical literature on investment, which uses the average return on capital to approximate marginal returns (Abel and Blanchard, 1986). This approximation is appropriate as long as the underlying production function has constant returns to scale. Further, as discussed in Gilchrist and Himmelberg (1999), using ROA to calculate the marginal product of capital requires the assumptions of no fixed costs and perfect competition. In the investment literature, which is primarily concerned with dynamics, these assumptions may be too strong at the firm-level. For the present purposes, where I focus on long-run differences in the return to capital across different countries, consistent with persistent differences in risk-free rates, these assumptions appear less onerous.

average of firms' earnings to assets ratio over the five years following bond issuance. This diminishes the effect that short-term fluctuations at the firm level have on my estimate of the firm's required rate of return. It also mirrors the median duration of corporate bond funding in my sample (5.7 years).

In my calculations, I measure firm return using EBITDA instead of the commonly used net income figure, in order to capture firm output in its broadest form after accounting for inputs, such as labor costs. As a result, this already accounts for potentially different labor shares across countries. Importantly, EBITDA measures output before subtracting firm interest expenses. This is key for my analysis since we know from the bond-level results that interest payments will vary directly with currency forward premia. Second, I look to abstract as cleanly as possible from differences in accounting treatments for depreciation or amortization, which may vary across countries and time periods.[39] However, as I discuss below, my findings are robust to alternative measures of firm output, which take into account potentially confounding factors that have previously been associated with differences in capital stocks across countries, such as differnces in depreciation rates or taxation (Table 1-A3).

In the regression analysis for firm ROA, I match each firm with the one-year forward premium of its local currency.[40] The regression is specified as

$$\overline{ROA}_{i,t+5} = \beta(r_t^j - r_t^\$) + X_{i,t}'\gamma_t + \theta_{k,t} + \epsilon_{i,t}, \tag{10}$$

where I control for industry-year fixed effects, indicated by θ, to account for cross-industry and cross-time variation in firm ROA. In addition, I include the same set of firm-level characteristics $X_{i,t}$, previously used in the bond-level regressions as additional controls.

Table 1-7 presents the results, with the coefficient of interest, $\hat{\beta}$, given in the first row. Consistent with the findings at the bond level, firm ROA shows strong positive alignment with the underlying domestic currency's forward premium. The estimated coefficient is large and strongly statistically significant, at 0.42 and with a standard error of 0.15.[41]

[39] This choice is further supported by recent evidence that, at least for US firms, the vast majority of firm borrowing is based on cash flows, measured with EBITDA (Lian and Ma, 2019).

[40] As before, I consider the firm's ultimate parent company's country of risk exposure, as determined by Bloomberg. In additional robustness checks, I document that the results persist when I match firms to their local currency based on the primary issuer firm's country designation in Factset.

[41] Based on the simple firm model discussed above, one may expect a coefficient of one. The estimated coefficient is biased downward in the full sample because it is estimated across all firms, even when some of these firms fund in foreign currency, where risk-free interest rates may differ from the local rate (see section 5.2). The coefficient also

As the other columns in the regression table show, the estimated coefficient is robust to the inclusion of additional controls. Industry-time fixed effects control for the possibility that systematic differences in firm ROA across industries drive my results, which they do not (column 2). In column 3, I add firm characteristics as in the bond-level regression and find that the coefficient on forward premia retains its size and significance. Some of these firm-level controls are possibly endogenous "bad controls" (Angrist and Pischker, 2009), because they may also be driven in part by the firm's required rate of return. For example, if firms face lower required rates of return, one may expect firms to be able to sustain higher leverage. However, firm leverage may also differ systematically across firms in different countries due to differences in other, unrelated matters, such as the relative taxation of debt and equity. To account for the possibility of cross-country variation in corporate structure, which may lead to unobservable variable bias, I include these additional regressors as a robustness check. However, even after controlling for these potentially endogenous firm characteristics, I continue to find a strong relationship between currency forward premia and firm ROA.

Lastly, I control for the possibility that forward premia only show a connection to firm ROA because forward premia may proxy for risk. First, I include sovereign risk, measured as the local sovereign CDS spread relative to the US CDS and find that the coefficient on the forward premium is broadly unaffected.[42] Apart from sovereign risk, forward premia may also be correlated with the average market beta of firms in a given country. In the spirit of a classic CAPM model, firms whose returns have a higher beta to the aggregate market should deliver higher returns, even if all firms face the same risk-free interest rate. I control for the possibility that aggregate stock market exposure drives my result with an additional variable. Here, I calculate the covariance of the local MSCI stock market index with the global stock market (MSCI Global) using monthly returns measured in US dollars and a rolling five-year window. While this measure does not capture firm-specific betas, which are not directly available since a number of firms in my sample are privately held, it adequately controls for unobserved variable bias at the country-level since all firms in a given

increases towards one when risk-free interest rate differentials are measured at longer maturities, which align more closely with the maturity structure of firm funding.

[42]The estimated coefficient on the sovereign CDS is large but counter-intuitively negative, indicating that firms in countries with high sovereign risk have low ROA. Since the limited availability of CDS spreads restricts the sample to only more recent years and because of the large variation in sovereign spreads during the financial and the European debt crisis, it may be more difficult to interpret this finding in the same structural sense as the results on forward premia. However, it is instructive that the inclusion of sovereign CDS renders all firm-level characteristics insignificant, while the coefficient on risk-free interest rate differentials persists.

country also share the same forward premium.[43]

While this part of the analysis does not allow for a detailed within-firm test in order to definitely rule out selection effects, the target coefficient's broad level of robustness to the inclusion of alternative explanatory variables gives support to the view that, as demonstrated at the bond-level in a cleanly identified setting, selection does not drive the observed relationship between currency forward premia and firm ROA.[44]

As before, I provide a range of additional robustness checks in the appendix. First, I document that my results do not depend on the long-term time window used to construct ROA. The coefficient is essentially the same when ROA is measured either contemporaneously to or over the year following a firm's bond issue (Table 1-A3). The results are also not sensitive to alternative inputs into the ROA calculation. Alternative measures of firm output deliver similar results. This includes using EBIT, which measures total earnings but subtracts depreciation and amortization and therefore takes into account potential differences in depreciation rates. I also include pre- and post-tax net income, which further removes interest expenses. I also replace firm assets with firm PPE (property, plants, and equipment), which measures physical rather than total assets, and I find that the relationship retains statistical significance. In addition, I also find that currency forward premia are reflected with a coefficient of almost exactly one in the return on equity (ROE), for which net income is scaled by firm book equity (Table 1-A3). Lastly, I find that my findings are robust to both country and firm fixed effects, which forces the regression to estimate the coefficient of interest purely from cross-time variation in forward premia and firm ROA. I also broaden the sample to include non-issuance years and find that the relationship between firm ROA and forward premia persists (Table 1-A3).

Importantly, the ROA result also persists when I use contemporaneous UIP violations, i.e. the ex-post realizations of currency returns, taking into account both differences in risk-free rates and changes in the nominal exchange rate (Table 1-A3). In addition, I test if different measures of risk-free rate differentials lead to different results. Firm ROA remains strongly connected to forward premia, even if they are calculated based on longer-dated instruments (Table 1-A3). In fact, using longer-term forward premia increases the size of the estimated coefficient towards unity, which is more closely aligned with the magnitude one may expect based on the simple model or the bond-level

[43] Since violations of covered interest rate parity have been substantially smaller than risk-free rate differentials and sovereign risk spreads and have only very rarely exceeded a few tenths of a percent over the course of the sample (Du et al. 2019), they are conceptually unlikely to have a meaningful effect on longer-run capital allocation.

[44] Furthermore, I find support for this claim in the standardized test for selection on unobservables based on Oster (2019), where the regression coefficient generates a test statistic $\delta = 2.22$, which convincingly clears the standard critical value of one (appendix A1).

results.

Not only is the relationship between firm ROA and risk-free interest rate differentials statistically significant and highly robust, but it is also of high economic significance. Figure 1-2 shows that differentiation in currency forward premia is connected to meaningful variation in firm ROA at the country level. In this graph, I average firm ROA and forward premia by country over all years in my sample. The x-axis shows that forward premia, or risk-free interest rate differentials of the local currency to the US dollar, show substantial differences between countries. Since 1995, risk-free rates have been low in Japan (JP) whereas they have been high in Australia (AU). At the same time, average firm ROA has also been substantially higher in Australia, where the average rate has been close to 15 percent, relative to 9 percent in Japan. While the difference between Australia and Japan is most striking, differences in ROA between countries appear to generally align with variation in the long-run relative levels of risk-free rates.[45] A rough calculation using the baseline regression coefficient in column 1 of Table 1-7 suggests that almost a third of the difference in firm ROA between Australian and Japanese firms, or 2 percentage points of ROA, can be related to differences in risk-free interest rates, which are equal to 4.4 percent on average over the sample period.

As a result, this analysis documents large, economically meaningful variation in firm ROA across firms and countries, aligned with differences in risk-free interest rates. In consequence, forward premia appear to be connected to the allocation of capital across firms. This is a new empirical observation and emphasizes the importance of risk-free interest rate differentials (and UIP violations) for macroeconomic outcomes.

In the literature on international capital allocation, it is an open question to what extent cross-country differences can be attributed to frictions that impede or limit the free flow of capital across borders (Caselli and Feyrer, 2007). In this context, it is important to highlight that recent literature on the fundamental causes of UIP violations demonstrates how differences in capital stocks, aligned with differences in risk-free rates, can occur even with frictionless capital markets.

In these models, the key innovation relative to earlier generations of international general equilibrium models is to allow for asymmetry in countries' exposure to global risk. For some countries,

[45] Some emerging economies, such as Turkey (TR) or Brazil (BR) appear to deviate from this relationship in the graph. This may well represent data quality issues, since emerging market issuers overall only account for 10 percent of the firm sample, so country-average ROA figures are more likely to be distorted by idiosyncratic firm developments in these countries.

local output shocks are more correlated with global consumption risk, for example due to differences in countries' relative importance for global output (Hassan, 2013) or due to different positions in global trade networks (Richmond, 2019). While the underlying drivers of country asymmetry may differ, the resulting dynamics are similar when added to an otherwise standard international real business cycle model with traded and non-traded goods. Complete financial markets allow for perfect risk-sharing between households in different countries. As a result, when local output suffers a negative shock, local households pull in more traded goods from abroad to make up for a shortfall in the domestic non-traded good. Since this makes the local non-traded good relatively scarce, it becomes more expensive in terms of the traded good and the local currency's real exchange rate appreciates.

When local output shocks are correlated with global output, local risk becomes harder to diversify and the domestic currency will exhibit counter-cyclical properties (i.e. it will tend to appreciate when global output is low). As a result, the currency has attractive hedging properties from the perspective of a global investor: while a risk-free bond denominated in the local currency still only delivers a fixed number of units of the domestic consumption bundle, the bundle's value in terms of traded goods will fluctuate with global output. In particular, it promises to be more valuable to the global investor when global consumption is low. Because of these hedging properties, real interest rates and expected currency returns of a "safe-haven" country will be low, and assets denominated in the local currency will similarly inherit the stochastic properties of the real exchange rate.

This process can directly explain differences in corporate bond yields and borrowing costs by currency. From the perspective of a global investor, holding credit risk constant, a corporate bond in a "safe" currency promises a higher hedge value than a corporate bond denominated in a currency with a more pro-cyclical exchange rate.[46] Commensurately, the bond will have a lower required rate of return, which means a lower borrowing cost from the perspective of the firm. However, this also means that firms that issue in low-interest rate currencies provide a hedge to global investors in exchange for lower funding costs (Eren and Malamud, 2019), and some firms may be able to do so more efficiently than others.

This insight connects the stochastic properties of the exchange rate to firm-level capital accumulation. At least in the non-traded sector, firms in countries with counter-cyclical exchange rates

[46] Appendix A2 discusses covariance between default risk and exchange rates.

will have higher capital stocks because they provide a natural hedge to global consumption. More capital accumulation in the non-traded sector firms of "safe-haven" countries increases the mean level of output of non-traded goods. Because this raises the amount of non-traded goods in safe countries in all states, this serves to cushion the effects of negative shocks, which are more likely to coincide with "bad" global conditions. From the perspective of households globally, increasing total output of non-traded goods in countries that are expensive to insure (i.e. "safe-havens") in all periods reduces the transfers to these countries in times when they are most costly.[47]

As a result, the two main findings in this paper provide micro-level evidence that is consistent with risk-based theories of UIP violations and currency risk, in particular as it pertains to the cost of capital and capital accumulation as predicted in Hassan, Mertens and Zhang (2016).

5 Foreign currency corporate bonds

So far, this paper has outlined two key findings that are new to the literature: first, cross-currency differentials in risk-free interest rates, and hence well-documented violations of UIP, directly pass through to corporate bond borrowing cost, and, second, risk-free rate differentials also appear to be closely related to cross-country variation in firm ROA, which is indicative of differences in capital allocation. The documented connection between firm ROA and local currency forward premia is consistent with the observation that most firms issue bonds denominated in their local currency. However, as part of the bond-level analysis in Table 1-7, I find that differences in risk-free interest rates are directly accessible to firms when they issue in different currencies.

Motivated by these observations, I explore how firms operate in international bond markets, and in particular, if foreign currency bond issuance is related to real outcomes at the firm level. If firms can access risk-free interest rates in other currencies, this may make firms less susceptible to the local interest rate environment, particularly if it substantially diverges from financial conditions elsewhere as indicated by large forward premia. After aggregating individual bonds to the issuer firm, my data set provides me with a comprehensive picture of the currency composition of bond issuance at the firm-level, which I explore in the following section.

[47] Because of global risk-sharing, there is no such benefit to firms in the traded sector in these models. In the data, the distinction is not as sharp, and I do not observe a statistically significant difference in the relationship between local currency forward premia and firm ROA for firms with high and those with low foreign sales; for example (Table 1-A3).

5.1 Currency composition of corporate bond issuance

On aggregate, and in alignment with the findings on the investor side in Maggiori et al. (2019), I find that non-financial firms generally issue bonds either in local currency or in US dollars. Figure 1-3 shows a scatterplot based on total gross issuance volume by country, with the share of total issuance denominated in the local currency on the y-axis and the issuance share of dollar-denominated bonds on the x-axis.

The first observation is that most countries are closely clustered along the diagonal, which marks the possibility frontier if firms split up bond issuance exclusively between the two currencies. Only a selected few countries are away from the line and closer to the origin. These economies (in particular, Denmark and Sweden) are adjacent to the euro area, and euro-denominated bonds account for almost all foreign currency issuance in these countries. The US is in the top right corner since US dollar and local currency issuance are synonymous. Reflecting the central role of the US dollar in corporate bond markets, US firms issue the smallest share of total volume in foreign currency among all countries in the sample.

Secondly, we observe that the relative use of foreign currency debt, and hence of US dollar-denominated bonds, varies substantially across countries. While firms in Europe and East Asia appear to issue mostly in local currency, firms in Latin America and major developed Anglo-Saxon economies, such as Canada, Australia, and the UK, rely more heavily on US dollar-denominated debt.

What factors may explain the substantial cross-country dispersion in currency composition, and may the dispersion be related to differences in risk-free interest rates? Based on having matched individual debt issues to the underlying issuers, I can observe the currency composition of bond issuance at the firm level. Simple graphical analysis presented as binscatters in Figures 1-4 and 1-5 shows that large firms and firms with high international sales issue a substantially lower share of their bonds in domestic currency, on average. These findings are intuitive. Firms with higher foreign sales exposure may want to hedge foreign currency-denominated earnings with debt denominated in the same currency. At the same time, the relationship between firm size and local currency issuance shares is consistent with the interpretation that firms may have to pay a fixed cost to access different currency markets because this may require firms to build relationships with a new investor base (Maggiori et al. 2019). This emphasizes that the currency composition of bond issuance at the firm level may depend on several different factors, which requires a more thorough empirical analysis.

I explore the relationship between foreign currency bond issuance and firm and country characteristics in a regression setting. Across all firms with observed bond issuance, I regress the share of total issuance that is denominated in local currency on a range of potentially relevant characteristics at the firm level. The list of variables includes firm size, international sales exposure, and the local currency's forward premium. I again account for cross-industry variation with industry-year fixed effects.

To be clear, this test highlights correlations between characteristics and the currency composition of bond issuance, which are not necessarily causal. Still, the regression results in Table 1-7 show that on average, firms have a lower share of local-currency denominated bond issuance when the risk-free interest rate differential of the domestic currency to the US dollar is large. The coefficient on the risk-free interest rate differential is estimated to be -4.2, with a standard error of 1.01, which indicates that the share of bond issuance denominated in the local currency decreases by 4 percentage points in association with a one percent increase in the local currency's interest rate differential to the US dollar, on average. This is quantitatively important since a 10 percentage point increase in the international sales share is only related to a 3.5 percentage decrease in the local currency issuance share. Moreover, the estimated regression coefficient implies that an Australian firm will on average have a *foreign* currency issuance share that is 18.5 percentage points above that of a similar Japanese firm, all else equal, given the regression coefficient and the average risk-free interest rate differential of 4.4 of percent over the course of my sample between the yen and the Australian dollar. The coefficient on the risk-free rate differential is robust to the inclusion of firm characteristics, in particular foreign sales exposure and firm size, which are both strongly related to the currency composition of bond issuance, as expected. Sovereign risk and violations of uncovered interest rate parity do not appear related to bond currency composition at the firm level in a statistically significant way.[48] In addition, once differences in risk-free interest rates are accounted for, firms in emerging markets do not appear to rely more on foreign currency bond markets than firms in developed markets. Firms in developed and in emerging markets have the same mean currency composition between local and foreign currency, as a dummy variable for emerging market firms is statistically insignificant in the regression.

[48] This is a subtly different finding relative to Liao (2019), who argues that firms may arbitrage differences in the net deviation of credit spreads across currencies, which may align with CIP violations.

Lastly, I consider the special status of US firms. For firms with foreign sales, foreign currency liabilities can serve as a natural (operational) hedge against changes in the nominal exchange rate, at least if both income streams and debts are denominated in the same currency. As a large literature on currency invoicing shows, a large amount of cross-border trade is commonly denominated in US dollars (Gopinath, 2015). The dominant position of the dollar on trade mirrors the unique role the US currency plays in corporate bond markets, since bonds issued in foreign currency are largely dollar-denominated, as shown in Figure 1-3. These observations fit together intuitively, since, under dollar invoicing, firms have a real hedging motive to issue dollar-denominated bonds, even when they sell to a third country.

At the same time, US firms are in a unique position since an increase in foreign sales should not increase the need for operational hedges. The data support this intuition: Figure 1-6 shows that US firms with a large share of international to total sales do not have substantially lower foreign currency issuance shares. Instead, even for firms that source almost all of their sales from abroad, the local currency issuance share is very close to 100 percent.[49]

More generally, US firms are an outlier relative to firms anywhere else when it comes to the currency composition of debt issuance. On average, as shown in column 6 of Table 1-7, a firm in the US will have a local currency issuance share that is 20 percent higher than that of an identical firm in any other country. While the role of the dollar as the dominant trade currency likely plays an important part, another intuitive consideration is the depth of financial markets. In contrast even to other developed markets, the US is unique in terms of its long history of corporate credit markets, even for non-financial firms. Even for firms at the very top end of the size distribution, US firms do not increase their foreign currency issuance share very much, while very large firms in other countries do so quite rapidly (Figure 1-7).

5.2 Foreign currency issuance and firm ROA

At the firm-level, I find strong evidence that high interest rates in the local currency are correlated with higher shares of foreign currency bond issuance. This is consistent with the interpretation that firms may issue in foreign currency to access more accommodative funding conditions and lower risk-free rates abroad. To test if we observe a related difference in real outcomes between firms with and

[49] Based on text analysis of conference calls of S&P 500 companies, Liao (2019) also provides suggestive evidence that for the small share of foreign currency-denominated bonds issued by US companies, firms may hedge the exchange rate exposure to some extent.

without foreign currency bond issuance, I return to the firm-level ROA regression from the previous section. If foreign currency bond issuers are less exposed to the domestic interest rate environment, then these firms should exhibit a weaker link between domestic risk-free rate differentials and firm ROA. I test this prediction in a regression of the following form:

$$\overline{ROA}_{i,t+5} = \left(\beta + \psi \mathbb{I}_{i,t}^{FC}\right)\left(r_t^j - r_t^\$\right) + X_{i,t}'\gamma_t + \theta_{k,t} + \epsilon_{i,t}. \tag{11}$$

Relative to equation (10), this regression adds an indicator term $\mathbb{I}_{i,t}^{FC}$, which is equal to one if I observe that firm i issues a bond in foreign currency in a given year, and zero otherwise. I interact this indicator with the domestic currency forward premium. As a result, the coefficient on this term measures the extent to which the link between firm ROA and the local risk-free rate differential is different among firms with and without foreign currency bond market access.

Table 1-7 presents the results of this regression. The coefficient on the standard forward premium, $\hat{\beta}$, is now larger at 0.57 with a standard error of 0.1, relative to 0.42 in the baseline regression in Table 1-7, because it is now only estimated over firms without foreign currency bond issuance, versus all firms in the sample previously. The new coefficient of interest, $\hat{\psi}$, is reported in the second row. It is quantitatively large at -0.34 and statistically significant with a standard error of 0.17. In combination, the coefficients indicate that the required rate of return of domestic currency issuers increases by 57 basis points, as approximated by ROA, for every percentage point of risk-free interest rate differential of the local currency to the US dollar. However, for firms that issue in foreign currency bond markets, the required rate of return only appears to increase by 23 basis points. As a result, the regressions suggest that foreign-currency issuers are substantially more insulated from the domestic interest rate environment since the local currency interest rate differential appears to be less directly related to firm ROA (and hence firm capital stocks).[50] This is likely because foreign currency issuance is mostly US dollar-denominated, and dollar risk-free rates tend to be low, which then may translate into lower required rates of return for the firm.

Since the results in the previous section show that foreign currency issuance is related to other underlying firm characteristics, these findings should be interpreted with caution. I take a three-pronged approach to deal with concerns about possible selection effects. First, I account for

[50] Table 1-A3 shows that this result is not related to how the firm's local currency is identified. The result is identical if the local currency is based on the underlying firm's immediate country of domicile instead of the firm's ultimate parent company's country of exposure.

differences in firm observables, which may be related to foreign currency borrowing access and sensitivity to local currency forward premia simultaneously. Column 2 in the regression table includes the standard set of firm characteristics from the previous regressions. This includes firm size and foreign sales exposure, which are strongly related to foreign currency issuance but the estimated difference in the relationship between ROA and local currency forward premia for foreign and domestic currency bond issuers retains its size and significance. As a result, observable differences between firms with and without foreign currency issuance cannot explain the different levels of sensitivity to risk-free rate differentials in the local currency.

Furthermore, I test if the result is due to systematic differences in mean ROA between the two groups of firms, but the indicator variable without interaction with the local forward premium is statistically insignificant in column 3 of the regression table. This shows that differences in firm ROA between domestic and foreign currency bond issuers only occur when local risk-free rates deviate from the global (US) interest rate environment, which is consistent with foreign currency bonds providing insulation from the local interest rate environment for the issuing firm.

Secondly, I test explicitly if the difference in sensitivity to local interest rates persists within subsamples of firms with similar ability or motives to issue foreign currency bonds. Table 1-7 repeats the regression, based only on firms that are above the median firm size, measured as total assets in US dollars. Since small firms are substantially less likely to issue in foreign currency, potentially because of the presence of fixed costs, the regression result above may simply represent different sensitivities to local interest rates among small and large firms. However, as the results in column 1 show, the difference between firms with and without foreign currency bonds is even larger and more statistically significant, at -0.41 and with a standard error of 0.15 when I only compare firms with total assets above the sample median. Similarly, my finding may be driven by selection along the axis of foreign exposure. In column 2, I re-estimate the regression based only on firms with below-median foreign sales exposure. Even among firms that are predominantly domestic in nature, the difference in sensitivity is large and strongly significant. Consistently, in the intersection of the two samples, i.e. firms that are likely to be able to access foreign currency markets because of their size but do not have a strong observable operational hedging motive to issue foreign currency bonds, the difference in sensitivities is large and statistically significant. In fact, the implied relationship between firm ROA and the local currency forward premium for foreign currency issuers with these characteristics is so weak that a one percentage point difference in local risk-free interest rates relative to the US is related to only a six basis point higher ROA at the firm level. Meanwhile, it is almost ten times larger for similar firms in this subsample that issue only in domestic currency. This finding shows that differentiation along firm observables is unlikely to explain the different relationships between ROA and local risk-free rates between the two groups of firms.

Lastly, I perform an additional test in the time series to account for potential differences in unobservables between foreign currency issuers and firms that only issue in domestic currency. Here, I rely on the panel structure of the data. Given that for individual firms, I observe issuance behavior over time, I can construct a dummy variable that is equal to one if I observe a given firm issuing a bond in foreign currency, or having done so in the past. I then run a simple regression of firm ROA on the new dummy variable, the standard set of firm characteristics, and firm-fixed effects. To account for common variation in ROA across time and industries, I again include industry sector-year fixed effects. The regression coefficient on the variable that captures foreign currency bond market entry measures whether ROA changes systematically for a given firm after it becomes a foreign currency issuer. The coefficient estimate is equal to -0.6 and is statistically significant with a standard error of 0.2. The coefficient, which is robust to the inclusion of firm-level controls, suggests that after a firm becomes a foreign currency issuer, firm ROA, measured over the following 5 years, falls by 60 basis points on average. As the median firm's ROA in the sample is equal to 10.5, this is an economically meaningful finding, especially given the inclusion of firm-fixed effects.

In sum, the evidence is consistent with the interpretation that foreign currency-denominated bond issuance allows firms to access different, and often lower, risk-free interest rates abroad, which may in part shield them from the local interest rate environment, where higher risk-free rates may lead to higher required rates of return.

This insight establishes a connection to other work that has documented real effects of foreign currency borrowing by firms. Salomao and Varela (2019) show that foreign currency issuers accumulate more capital in emerging markets and develop a model of endogenous funding currency choice. In turn, my findings are consistent with the interpretation that their results are relevant for firms globally since only 10 percent of my sample is made up of emerging market firms.[51] Furthermore, the observation that foreign currency issuance insulates firms from the domestic interest rate environment is relevant to recent research on the behavior of investors. In portfolio-level data, Maggiori, Neiman and Schreger (2019) document that investors almost exclusively hold assets denominated

[51]Emerging market firms make up 15 percent of all foreign-currency issuer firms.

in their local currency or in US dollars. As a result, they find that firms can only raise funds from foreign investors if they issue dollar-denominated bonds. My findings are consistent with the interpretation that investor segmentation along currency denomination may have real consequences for borrowing costs and the allocation of capital across firms and countries.

5.3 Firm heterogeneity in the pass-through of risk-free rate differentials

We observe heterogeneity in the sensitivity of individual firms to their local interest rate environment in alignment with the currency composition of their bonds because foreign currency bonds may provide access to different, i.e. lower funding costs in foreign currency. In addition to heterogeneity between firms with and without foreign currency bond issuance, I now explore if there is additional heterogeneity in the ability of firms to capture differences in risk-free interest rates among multi-currency issuers.

Based on the underlying information at the firm level, I perform an additional set of tests, which estimate the extent to which the pass-through of risk-free interest rate differentials may differ along firm characteristics. To do so, I re-run the within-firm regression specification from section 3 and include an additional term that allows for different pass-through coefficients based on firm characteristics. The regression specification is then

$$y_{i,t}^{j,d} - r_t^{\$,d} = \kappa_{i,t} + \left(\beta + \psi \mathbb{I}_{i,t}^{M}\right) \left(r_t^{j,d} - r_t^{\$,d}\right) + \omega_{m,t} + \epsilon_{i,t}, \tag{12}$$

where the ψ coefficient measures the difference between the pass-through coefficient for firms that are above the sample median of a given characteristic, and those that are not. For example, the indicator is equal to one for firms with total assets above the sample median, and zero for those with total assets lower than the median. In Table 1-7, the second row shows the estimate for the ψ coefficient. The coefficient on the indicator, based on firm size in column 1 and firm leverage in column 2, interacted with the local currency forward premium, is not statistically distinguishable from zero. This show that, conditional on a firm issuing in multiple currencies in the first place, the ability to capture risk-free interest rate differentials does not appear to be different between large and small firms, or between firms with high or low leverage. Interestingly, a firm's foreign exposure, measured as the international share of total sales, also does not appear related to the pass-through coefficient, which indicates that domestic and international firms all appear to have the same ability to access foreign financing conditions. Because we only observe this result for firms that actively issue in multiple currencies, the data are potentially censored. One could imagine that firms without the ability to capture the full risk-free rate differential may issue only in a single currency.

At least for a particular group of firms that are commonly faced with high local currency risk-free rates relative to the dollar, this does not appear to be the case. As shown in column 4, there appears to be a significant difference in the pass-through coefficient for firms that are located in developed markets (where the pass-through coefficient is tightly estimated at 0.94 with a standard error of 0.01) compared to firms in emerging markets. For the latter group of firms, the pass-through coefficient is estimated to be smaller by 0.38, with a standard error of 0.07, which implies that only a little over half of the difference in risk-free interest rates is passed through to corporate bond yields of these firms. This means that a firm in a developing economy with high local currency forward premia is not able to capture the full risk-free rate differential between its local currency and the US dollar by issuing a dollar-denominated bond.

The lower pass-through coefficient for firms in emerging markets is an interesting insight from an asset pricing perspective since it is consistent with the interpretation that there is a connection between firm default and exchange rate (”quanto”) risk (Kremens and Martin, 2019). The fact that the coefficient is substantially below unity implies that for a US dollar-based investor, buying a bond denominated in the firm's local (high risk-free rate) currency and hedging it back into US dollars using currency forwards, delivers a lower yield than buying the firm's dollar-denominated bond, even in absence of transaction costs. Transaction costs may be substantial, however,which would lower the expected return on the hedged bond even further from the investor's perspective, worsening the puzzle. As I discuss the underlying mechanics formally in the appendix (section A2), correlation between default risk and the firm's local currency's exchange rate may explain this observation, as the currency forward may provide some hedge value in the case of default.[52] This finding on the limited ability of EM firms to capture differences in risk-free interest rates is relevant for work that studies the role of foreign currency corporate borrowing (Bruno and Shin, 2017; Gopinath and Stein, 2018; Salomao and Varela, 2019). These papers make the implicit assumption that differences in risk-free rates between the firm's local currency and foreign currency, often the US dollar, are

[52]While credit risk in both bonds should generally be the same given cross-default clauses, there may be other potential reasons for the resulting differences, such as government intervention or legal enforcement, though it is unclear in which direction these factors should drive relative risk in two bonds by the same emerging market company. For example, if dollar-denominated bonds fall under US jurisdiction and hence provide better creditor protection, then one would expect the yield on the dollar bond to be below that of the hedged local currency bond, which is the opposite of what I find in the data.

directly accessible to the firm. The data from corporate bond markets show that this may only be true to a limited extent.

6 Conclusion

In this paper, I document that UIP violations and differences in risk-free rates have first-order effects on firms in the non-financial sector, in particular on their borrowing costs in bond markets and the firm-level cost of capital. Based on a large, novel data set on security-level corporate bond issuance, I document that risk-free interest rate differentials directly pass through to corporate borrowing rates, at the rate of almost one-for-one. As violations of UIP extend to corporate bond markets, firms face substantially different borrowing costs depending on the currency denomination of their bonds.

Furthermore, this connection between firm borrowing costs and forward premia appears to be reflected in real outcomes, as firm-level ROA varies strongly with risk-free rate differentials. Since ROA may be thought of as representative of a firm's required rate of return on capital, this is consistent with the interpretation that risk-free interest rate differentials have a meaningful effect on the allocation of capital across firms. This effect is economically large as I observe large, persistent differences in ROA and risk-free interest rates across countries. Lastly, I find evidence suggestive of a firm response. When local risk-free interest rates are high, firms appear to issue more bonds in foreign currency. Furthermore, and consistent with this perspective, I find that foreign-currency issuer firms appear to be more insulated from their domestic interest rate environment, as they exhibit a significantly weaker link between local interest rates and firm ROA.

In conclusion, this paper provides strong evidence that risk-free interest rate differentials and UIP violations between currencies are directly connected to the variation in firm borrowing costs and the allocation of capital. At the same time, I show that firm heterogeneity in access to international financing markets appears to be connected to real effects. This finding provides motivation and economic relevance for future research on the determinants of firm funding currency choice and the effects of heterogeneity in firm access to international financing.

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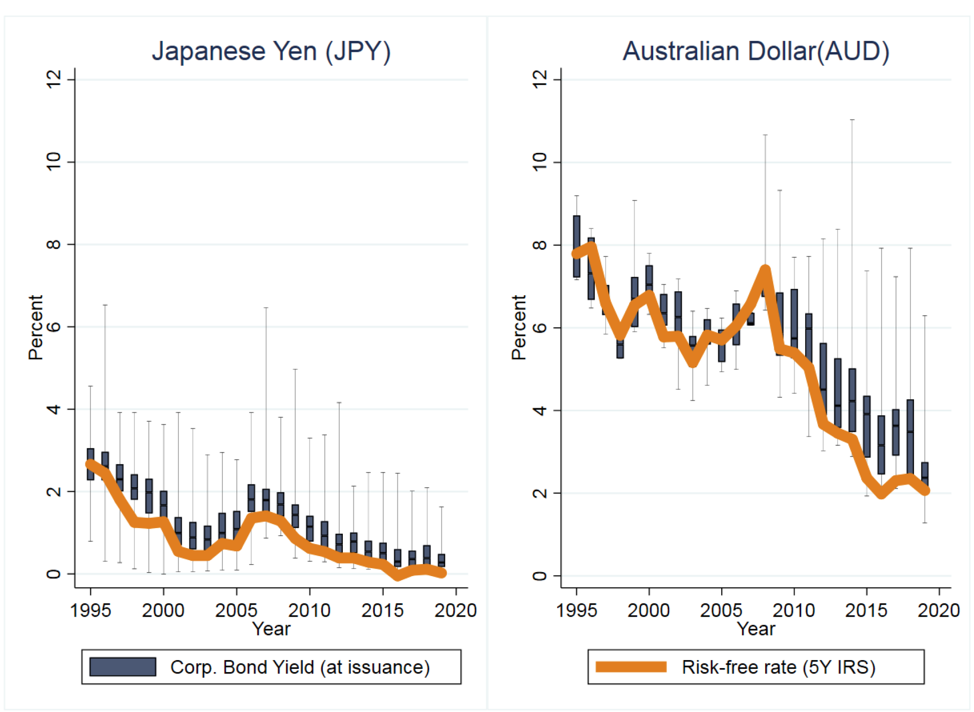
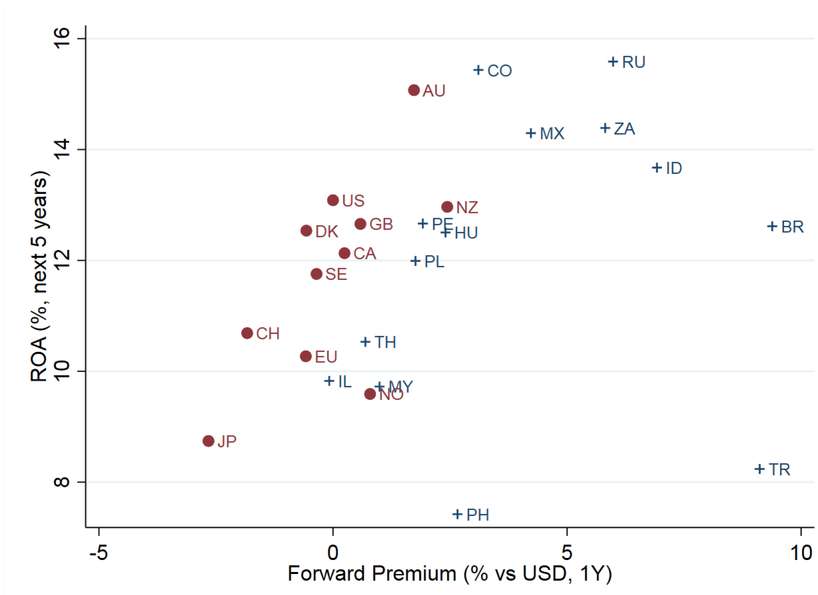
Figure 1-1: Yields of corporate bonds denominated in Japanese Yen (JPY) and Australian Dollar (AUD) over time



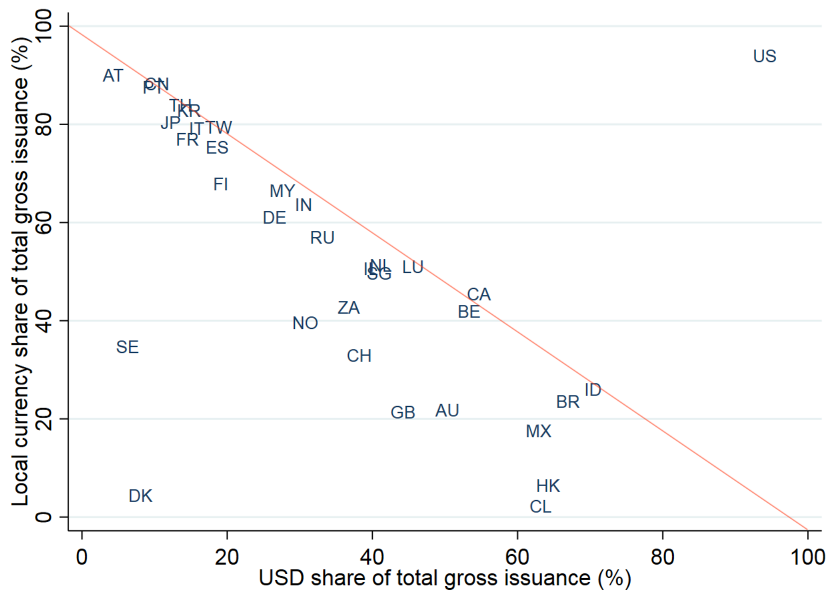
Notes: Each box plot captures the distribution of all corporate bonds issued in Japanese Yen or Australian Dollar, respectively, issued in the given year. Boxes describe the interquartile range (25th-75th percentile) while whiskers capture minimum and maximum values. Yields are measured at issuance, representing the actual financing cost to the firm. The line represents the 5-year risk-free interest rate, measured using each currency's interbank interest rate swap. Data is annual from 1995 to 2019.

Figure 1-2: Firm cost of capital and local currency interest rate differential



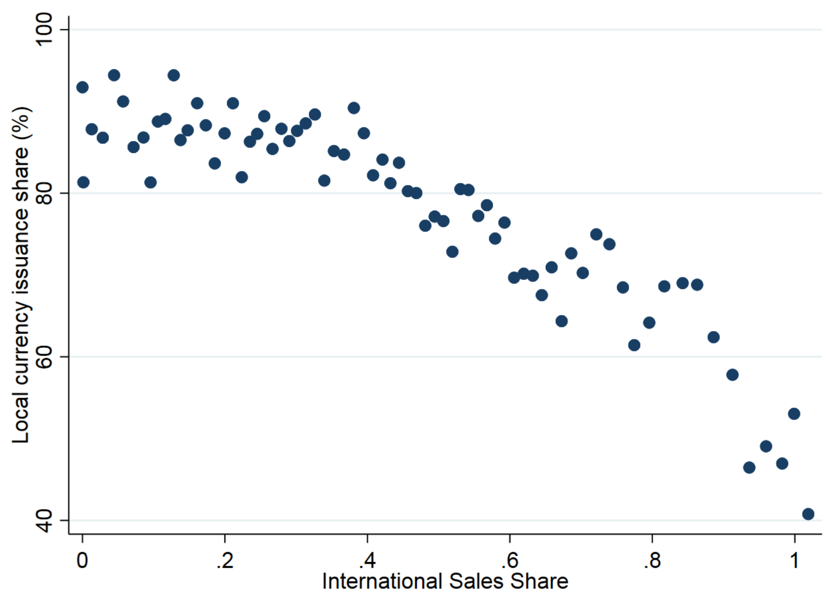
Notes: Average firm ROA of all issuers in a given country, versus the country's forward premium. The forward premium captures the 1-year interest rate differential priced into currency forwards, and each firm is assigned the local currency of its ultimate parent company's country of risk (consistent with BIS methodology). The earnings to assets ratio is calculated as the ratio of EBITDA to total firm assets, averaged over the next five years, and measures firm cost of capital, or firm output-to-capital ratio. Data is averaged over 1995 to 2019. Blue color + denote emerging markets.

Figure 1-3: Currency composition of bond issuance



Notes: Issuance share denotes the percentage of total gross bond issuance by non-financial corporations in each country, either in local currency or in US Dollars. Data runs from 1995 to 2019.

Figure 1-4: Local currency issuance share and firm international sales exposure

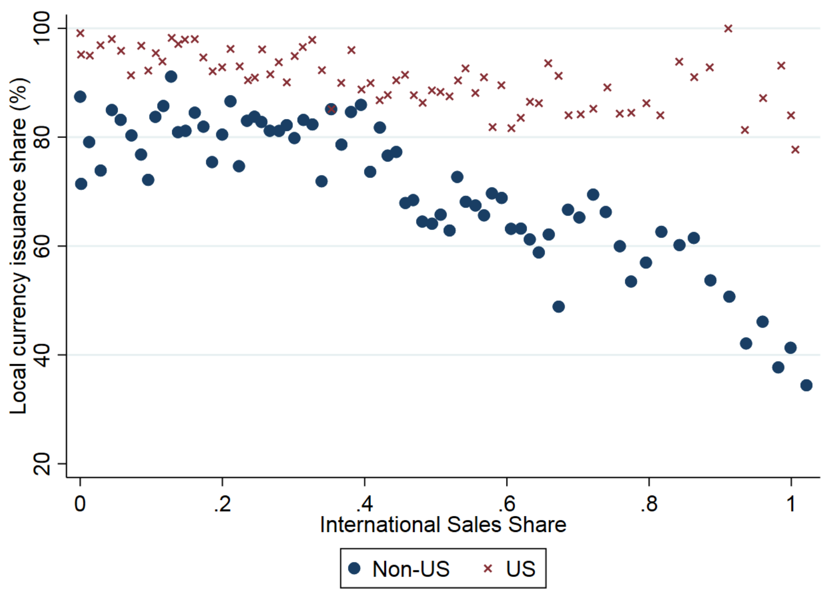


Notes: Binscatter. Each dot accounts for around 200 firm-year observations. Local currency issuance share denotes the percentage of total gross bond issuance denominated in local currency. Firm international sales exposure measures the ratio of international to total firm sales. Data runs from 1995 to 2019.

Figure 1-5: Local currency issuance share and firm size

Notes: Binscatter. Each dot accounts for around 200 firm-year observations. Local currency issuance share denotes the percentage of total gross bond issuance denominated in local currency. Firm size is measured as the log of total firm assets, measured in current US Dollars, converted at yearly average spot exchange rates. Data runs from 1995 to 2019.

Figure 1-6: Local currency issuance share vs firm international exposure, US vs RoW



Notes: Binscatter. Local currency issuance share denotes the percentage of total gross bond issuance denominated in local currency. International Sales share is measured as foreign sales divided by total sales. Data runs from 1995 to 2019.

Figure 1-7: Local currency issuance share vs firm size, US vs RoW

Notes: Binscatter. Local currency issuance share denotes the percentage of total gross bond issuance denominated in local currency. Firm size is measured as the log of total firm assets, measured in current US Dollars, and converted at year-average spot exchange rates. Data runs from 1995 to 2019.

Table 1-1: Summary statistics for corporate bond and issuer firm data sets

	N	Mean	Median	St. Dev	P10	P90
Panel A: Corporate Bonds						
Yield-to-maturity(%)	52,909	4.85	4.83	2.64	1.41	8.08
US risk-free rate(%)	52,909	3.48	2.89	1.99	1.22	6.39
Forward premium (%)	52,909	-0.36	0.00	1.61	-2.47	0.72
CIP Violation (%)	44,565	-0.12	0.00	0.36	-0.45	0.00
CDS differential (%)	25,029	0.25	0.00	0.75	-0.02	0.84
Amount Issued (USD bn)	52,909	0.31	0.13	0.46	0.01	0.8
Maturity (years)	52,909	9.12	7.04	8.31	3.02	20.05
Duration	52,139	6.51	5.68	3.75	2.76	11.64
Panel B: Firms						
Issuance Volume (USD bn, year)	14,250	1.05	0.43	2.13	0.01	2.40
Size (USD bn)	13,306	25.53	8.65	52.37	0.92	60.32
Size (log)	13,306	8.96	9.06	1.60	6.87	10.92
$\overline{ROA}_{i,t}$	12,131	11.30	10.50	6.06	4.81	19.21
$\overline{ROA}_{i,t+5}$	8,736	11.35	10.59	5.37	5.36	18.45
Leverage(%)	13,301	35.28	33.55	17.39	15.76	56.22
Cash holdings (%)	13,171	28.29	23.47	21.00	5.46	59.18
International Sales Share	12,473	0.32	0.26	0.31	0.00	0.8

Notes: This table describes the bond- and firm-level data sets constructed in this paper. An observation in the corporate bond database is a single bond, identified by a unique ISIN. Yield to maturity and all other variables are as of initial issuance. The US risk free interest rate is calculated using interest rate swaps, and are matched to the duration of each underlying corporate bond. Duration matching also applies to forward premia, capturing the interest rate differentials between the bond's currency denomination and the US Dollar, and the cross-currency basis for the same currency pair. Bond size denotes the total amount issued in US Dollars, converted at the spot exchange rate at issuance. Bond maturity and duration are calculated relative to the original issuance date. All bonds in this sample have either a fixed or a zero coupon to allow for cross-comparison. The firm data set consists of the firms to which individual bonds can be matched, by year. Each observation is at the firm-year level. There are 4800 individual firms in the data set. Issuance volume represents the total amount raised with corporate bonds, converted at spot exchange rates. Firm size is defined as total firm assets, and is presented in Dollars and in logs. Return on assets (ROA) is calculated as the Data runs from 1995 to 2019.

Table 1-2: Pass-through of risk-free interest rate differentials to corporate bond yields

		$y^{j,d}_{i,t} - r^{\$,d}_{t}$			$y^{j,d}_{i,t} - r^{\$,d}_{t} + \Delta s^{j,d}_{t+d}$	
	(1)	(2)	(3)	(4)	(5)	(6)
$r^{j,d}_{t} - r^{\$,d}_{t}$	1.099***	1.064***	1.070***	0.691***	0.698***	0.690***
	(0.061)	(0.046)	(0.061)	(0.139)	(0.163)	(0.191)
Firm Size			-0.332***			-0.424***
			(0.043)			(0.046)
Firm Leverage			0.016***			0.019***
			(0.003)			(0.004)
Firm Cash/Assets			0.005***			0.005**
			(0.002)			(0.002)
Firm Int'l Sales Exposure			0.283			0.308
			(0.188)			(0.334)
N	52731	33861	30072	43103	27236	23999
R^2	0.47	0.65	0.73	0.07	0.27	0.31
Maturity-Year FE	Y	Y	Y	Y	Y	Y
Sector-Year FE		Y	Y		Y	Y

SEs in parantheses, clustered by country. *p<0.1, **p<0.05, ***p<0.01

Notes: The dependent variable in columns 1 through 3 is the difference between the corporate bond yield to the duration-matched US risk-free rate (IRS). In order to approximate realized effective borrowing cost in common currency, columns 4 through 6 add the realized appreciation in the nominal exchange rate of the bond's currency of denomination to the USD, annualized, over the duration of the bond. Risk-free interest rate differentials are measured using currency forward premia and currency swaps (Du and Schreger, 2016), and match the underlying corporate bond's duration. Firm size is measured as the log of firm total assets, all other firm characteristics are calculated as ratios to firm assets or sales. All firm information is contemporaneous to bond issuance. Sovereign CDS is measured as the CDS spread of the respective underlying sovereign's USD-denominated debt, relative to the contemporaneous US government CDS. Data runs from 1995 to 2019.

Title 1-3: Pass-through of risk-free interest rate differentials to corporate bond yields within firms

	$y_{i,t}^{j,d} - r_t^{\$,d}$		$y_{i,t}^{j,d} - r_t^{\$,d} + \Delta s_{t+d}^{j,d}$	
	(1)	(2)	(3)	(4)
$r_t^{j,d} - r_t^{\$,d}$	0.849***	0.924***	0.439*	0.621***
	(0.068)	(0.025)	(0.248)	(0.230)
N	39766	28548	32136	22742
R^2	0.90	0.91	0.77	0.85
Firm-Year FE	Y		Y	
Firm-Month FE		Y		Y

SEs in parantheses, clustered by country. *p<0.1, **p<0.05, ***p<0.01

Notes: The dependent variable in columns 1 and 2 is the difference between the corporate bond yield to the duration-matched US risk-free rate (IRS). In order to approximate realized effective borrowing cost in common currency, columns 3 and 4 add the realized appreciation in the nominal exchange rate of the bond's currency of denomination to the USD, annualized, over the duration of the bond. Risk-free interest rate differentials and CIP violations are measured using currency swaps and interbank interest rate swaps (Du and Schreger, 2016). Data runs from 1995 to 2019.

Table 1-4: Pass-through of risk-free interest rate differentials, sovereign CDS and CIP violations to corporate bond yields

	$y_{i,t}^{j,d} - r_t^{\$,d}$					
	(1)	(2)	(3)	(4)	(5)	(6)
$r_t^{j,d} - r_t^{\$,d}$	1.101***	1.091***	0.927***	0.917***	0.955***	0.918***
	(0.084)	(0.102)	(0.0129)	(0.017)	(0.016)	(0.015)
CDS Differential (firm-matched)	0.276***	0.125				
	(0.0839)	(0.130)				
CDS Differential (bond-matched)			0.091	0.105		
			(0.146)	(0.180)		
CIP violation					-0.213	0.036
					(0.147)	(0.056)
N	18417	16918	18246	13728	33150	24455
R^2	0.58	0.66	0.89	0.89	0.86	0.88
Maturity-Year FE	Y	Y	Y	Y	Y	Y
Sector-Year FE	Y	Y	Y	Y	Y	Y
Controls: Firm Characteristics		Y				
Firm-Year FE			Y		Y	
Firm-Month FE				Y		Y

SEs in parantheses, clustered by country. *p<0.1, **p<0.05, ***p<0.01

Notes: Risk-free interest rate differentials are measured using currency forward premia and currency swaps (Du and Schreger, 2016), and match the underlying corporate bond's duration. Sovereign CDS is measured as the CDS spread of the respective underlying sovereign's USD-denominated debt, relative to the contemporaneous US government CDS. In columns 1 and 2, I match each bond to the respective sovereign CDS of the firm's ultimate parent company's country of origin. In column 3 and 4, I match each bond to the CDS based on the currency denomination of the bond (Euro-denominated bonds are matched to the German government CDS. CIP violations are measured as the cross-currency basis of the bond's currency of denomination, relative to the US Dollar, and is matched to the duration of the underlying bond. Column 2 includes unreported controls for firm characteristics as used in Table 2, which include firm size, firm leverage, firm cash holdings relative to total assets, and the firm's international sales share. Data runs from 1995 to 2019.

Table 1-5: Pass-through of risk-free interest rate differentials to firm-level cost of capital

	$\overline{ROA}_{i,t+5}$			
	(1)	(2)	(3)	(4)
$r_t^j - r_t^\$$	0.424***	0.387***	0.541***	0.446***
	(0.145)	(0.123)	(0.198)	(0.108)
Firm Size		0.157	0.265	0.149
		(0.137)	(0.185)	(0.136)
Firm Leverage		-0.018**	-0.015	-0.018**
		(0.007)	(0.013)	(0.007)
Firm Cash/Assets		-0.017*	-0.006	-0.017
		(0.009)	(0.007)	(0.009)
Firm Int'l Sales Exposure		1.293*	1.106	-1.578***
		(0.714)	(0.666)	(0.577)
Sovereign CDS (5y vs US)			-1.458**	
			(0.608)	
Equity Covariance				571.6
				(444.6)
N	8740	7910	4443	7910
R^2	0.24	0.26	0.22	0.27
Sector-Year FE	Y	Y	Y	Y

SEs in parantheses, clustered by country. *p<0.1, **p<0.05, ***p<0.01

Notes: Firm ROA is measured as the ratio of firm earnings (EBITDA) to total assets over the next five years. Risk-free interest rate differentials are measured using currency forward premia at the 1-year maturity point. Firm size is measured as the log of firm total assets in USD, all other firm characteristics are calculated as ratios to firm assets or sales. All firm information is contemporaneous to bond issuance. Sovereign CDS is measured as the CDS spread of the respective underlying sovereign's USD-denominated debt, and calculated relative to the US government CDS. Equity covariance measures the covariance between the local economy's MSCI equity index with the MSCI global stock index (both in USD), based on monthly returns over a five-year rolling window. Data runs from 1995 to 2019.

Table 1-6: Firm-level currency composition in bond issuance

	Local Currency Share of Total Bond Issuance (%)					
	(1)	(2)	(3)	(4)	(5)	(6)
$r_t^j - r_t^\$$	-4.187***	-4.471***	-4.896***	-3.365***	-3.851***	-5.155***
	(1.087)	(1.009)	(1.632)	(1.455)	(1.363)	(0.879)
Firm Size		-1.942***	-2.169***	-1.289*	-2.161***	-2.686***
		(0.891)	(0.839)	(0.652)	(0.800)	(0.947)
Firm Leverage		-0.037	-0.042	-0.008	-0.036	-0.050*
		(0.030)	(0.024)	(0.025)	(0.026)	(0.0276)
Firm Cash/Assets		-0.087	-0.046	-0.028	-0.079	-0.079
		(0.055)	(0.059)	(0.036)	(0.054)	(0.049)
Firm Int'l Sales Exposure		-35.02***	-35.21***	-29.71***	-35.27***	-27.31***
		(6.720)	(5.866)	(5.445)	(6.558)	(6.667)
Sovereign CDS (5y vs US)			0.0356			
			(6.117)			
CIP Violation				10.77		
				(11.93)		
Emerging Markets					-8.383	
					(10.97)	
US						19.46***
						(4.205)
N	14250	12103	8386	11160	12103	12103
R^2	0.07	0.23	0.22	0.18	0.23	0.29
Sector-Year FE		Y	Y	Y	Y	Y

SEs in parantheses, clustered by country. *p<0.1, **p<0.05, ***p<0.01

Notes: The local currency issuance share is equal to the percentage of total bond issuance volume in a given year that is denominated in the firm's local currency. Risk-free interest rate differentials are measured using currency forward premia at the 1-year maturity point. Firm size is measured as the log of firm total assets in USD, all other firm characteristics are calculated as ratios to firm assets or sales. All firm information is contemporaneous to bond issuance. Sovereign CDS is measured as the CDS spread of the respective underlying sovereign's USD-denominated debt, relative to the US government CDS. The cross-currency basis measures violations of covered interest rate parity, i.e. the difference between the interest rate differential implied by interest rate swaps and cross-currency swaps, respectively. Emerging markets describes a dummy variable that is equal to one for all firms located in countries that are designated emerging market economies by the IMF WEO publication. US describes a dummy variable that is equal to one for all firms in the US. Data runs from 1995 to 2019.

Table 1-7: Pass-through of risk-free interest rate differentials to firm-level cost of capital for foreign- and domestic-currency bond issuers

	$\overline{ROA}_{i,t+5}$		
	(1)	(2)	(3)
$r_t^j - r_t^\$$	0.570***	0.520***	0.527***
	(0.100)	(0.073)	(0.085)
$(r_t^j - r_t^\$) \cdot \mathbb{I}_{i,t}^{FC}$	-0.343*	-0.310*	-0.305*
	(0.173)	(0.163)	(0.155)
Firm Size		0.166	0.173
		(0.140)	(0.149)
Firm Leverage		-0.016**	-0.016**
		(0.007)	(0.007)
Firm Cash/Assets		-0.016*	-0.016*
		(0.008)	(0.008)
Firm Int'l Sales Exposure		1.190*	1.254*
		(0.678)	(0.700)
$\mathbb{I}_{i,t}^{FC}$			-0.16
			(0.377)
N	8740	7910	7910
R^2	0.24	0.27	0.27
Sector-Year FE	Y	Y	Y

SEs in parantheses, clustered by country. *p<0.1, **p<0.05, ***p<0.01

Notes: Firm ROA is measured as the ratio of firm earnings (EBITDA) to total assets over the next five years. Risk-free interest rate differentials are measured using currency forward premia at the 1-year maturity point, and firms are assigned the forward premium of their domestic currency, based on the ultimate parent company's country of risk designation in Bloomberg. The second row denotes the forward premium a second time, interacted with a dummy variable that equals one if the firm issues a foreign currency bond in a given year. Firm size is measured as the log of firm total assets in USD, all other firm characteristics are calculated as ratios to firm assets or sales. All firm information is contemporaneous to bond issuance. The last row denotes a foreign currency dummy variable, without the interaction with the local currency forward premium. Data runs from 1995 to 2019.

Table 1-8: Pass-through of risk-free interest rate differentials to firm-level cost of capital for foreign- and domestic-currency bond issuers: firm subsamples

	$\overline{ROA}_{i,t+5}$		
	Large Firms	Domestic Firms	Large & Domestic
	(1)	(2)	(3)
$r_t^j - r_t^\$$	0.588***	0.599***	0.526***
	(0.091)	(0.076)	(0.072)
$\left(r_t^j - r_t^\$\right)\mathbb{I}_{i,t}^{FC}$	-0.414**	-0.460**	-0.462***
	(0.153)	(0.125)	(0.146)
N	5622	4564	2723
R^2	0.34	0.32	0.42
Sector-Year FE	Y	Y	Y

SEs in parantheses, clustered by country. *p<0.1, **p<0.05, ***p<0.01

Notes: Firm ROA is measured as the ratio of firm earnings (EBITDA) to total assets over the next five years. Risk-free interest rate differentials are measured using currency forward premia at the 1-year maturity point, and firms are assigned the forward premium of their domestic currency, based on the ultimate parent company's country of risk designation in Bloomberg. The second row denotes the forward premium a second time, interacted with a dummy variable that equals one if the firm issues a foreign currency bond in a given year. Column 1 is based on a subsample of firms with firm size above the sample median. Column 2 is based on a subsample of firms with an international sales share below the sample median, and column 3 uses a sample with only those firms that are both above the median size, and below the median international sales share. Data runs from 1995 to 2019.

Table 1-9: Effects of foreign currency bond market access: within-firm

	$\overline{ROA}_{i,t+5}$	
	(1)	(2)
Entry in FC bond market	-0.566**	-0.596***
	(0.210)	(0.277)
Firm Size		-1.215***
		(0.205)
Firm Leverage		0.006***
		(0.004)
Firm Cash/Assets		-0.011**
		(0.004)
Firm Int'l Sales Share		0.247
		(0.712)
N	9937	8889
R^2	0.86	0.87
Sector-Year FE	Y	Y
Firm FE	Y	Y

SEs in parantheses, clustered by country. *p<0.1, **p<0.05, ***p<0.01

Notes: Firm ROA is measured as the ratio of firm earnings (EBITDA) to total assets, on average over the next five years. The first row, "entry into FC bond market" equal to 1 if the firm issues bonds in foreign currency in a given year, or has done so in the past. The sample includes non-issuance years. Data runs from 1995 to 2019.

Table 1-10: Pass-through of risk-free interest rate differentials to corporate bond yields by firm characteristics

	$y_{i,t}^{j,d} - r_t^{\$,d}$			
	Large Firms	High Leverage	High Int'l Sales Share	Emerging Markets
	(1)	(2)	(3)	(4)
$r_t^{j,d} - r_t^{\$,d}$	0.725***	0.898***	0.873***	0.942***
	(0.156)	(0.058)	(0.082)	(0.008)
$(r_t^{j,d} - r_t^{\$,d}) \cdot \mathbb{I}_{i,t}^{group}$	0.184	-0.000	-0.033	-0.375***
	(0.139)	(0.035)	(0.067)	(0.071)
N	24544	24598	23541	39510
R^2	0.90	0.90	0.92	0.90
Sector-Year FE	Y	Y	Y	Y
Firm-Year FE	Y	Y	Y	Y

SEs in parantheses, clustered by country. *p<0.1, **p<0.05, ***p<0.01

Notes: Risk-free interest rate differentials are measured using currency forward premia (or currency swaps, Du and Schreger, 2016). The second row captures the coefficient on the forward premium added a second time, interacted with a dummy variable that is equal to one if the underlying firm is above the sample median for firm size, leverage, or international sales exposure. The last column proceeds similarly, with the interaction being equal to one if the firm's underlying country of risk exposure is considered an emerging market by the IMF. Data runs from 1995 to 2019.

A0 Appendix

A1 Selection on Unobservables

In the preceding analysis, at the bond- and at the firm-level, a fundamental concern has been possible selection effects. If firms that borrow in currencies with higher risk-free rates were to have fundamentally higher credit risk (or other features that are positively correlated with the residual), then the estimates from the pass-through regression would be systematically biased. Similar concerns about selection on unobservables at the firm-level apply.

While I discuss my preferred identification scheme in the main body of the paper, a growing literature has recently made use of a formalized test to establish robustness to omitted variable bias. Historically, researchers have often interpreted the stability of the coefficient of interest to the inclusion of additional controls as a sign that selection bias is unlikely to drive an empirical relationship. Oster (2019) proposes an explicit test of this intuition, which takes the following form:

$$\beta^* = \tilde{\beta} - \delta \left[\dot{\beta} - \tilde{\beta}\right] \frac{R_{max} - \tilde{R}}{\tilde{R} - \dot{R},} \tag{13}$$

where β^* and R_{max} denote the true coefficient of interest and R^2, while $\tilde{\beta}$ $\tilde{R}$ denote the same for the regression *with*, and $\dot{\beta}$ $\dot{R}$ do so for the regression *without* observable controls. The parameter δ captures how strongly the unobserved variable must be correlated with the variable of interest, relative to the observable controls, in order to confound the estimated relationship (i.e., $\beta^* = 0$). In practice, Oster (2019) argues that $\delta = 1$ is a useful critical value, since it implies that the chosen observable control variables are at least as important as the unobservables. Furthermore, it is standard to calculate $R_max = min(1.3\tilde{R}, 1)$ in order to allow for measurement errors and similar concerns.

Under this test specification, I find that my regressions at the bond-level (without firm-time fixed effects, as presented in table 2) pass the test for selection on unobservables, with $\delta = 1.22$. So the underlying unobservables would need to be at least as important as all the previously controlled-for firm characteristics, such as size and leverage, in order for unobserved variable bias to explain all of the estimated relationship between risk-free interest rate differentials and corporate bond yields. Similarly, the coefficient on the forward premium in the firm-level ROA regressions passes this test, with $\delta = 2.22$. As a result, there is formalized statistical evidence that my results are not driven by unobserved variable bias.

A2 Limited pass-through and quanto risk

In the bond-level regressions documeting the pass-through of risk-free interest rate differentials to corporate bond yields only one group of firms appears to have a susbtantially lower pass-through coefficient than one. Firms in emerging markets appear to borrow in corporate bond markets with bond yields that differ by less than what risk-free interest rate differentials between the issuance currencies would suggest. In practice, this means that an emerging market firm in a high-risk-free interest rate country will face yields on US Dollar-denominated bonds that are higher than what is implied by the local currency-denominated corporate bond and the risk-free interest rate differential between the local currency and the dollar. Since risk-free interest rate differentials are measured with the forward premium, which approximates the cost of hedging out the nominal exchange rate risk, this means that in practice, the yield on a US Dollar-denominated bond is higher than the yield on a local currency bond, after it is hedged back into US Dollars, at least for firms in emerging markets.

This is a strinking observation since transaction costs, often a concern in derivative markets, would make the local currency bond yield even lower from the perspective of a US Dollar-based investor (relative to the Dollar-denominated bond where no currency hedging would be necessary). This is puzzling because the inherent credit risk in the two bonds, given cross-default clauses is assumed to be the same.

There are a number of possible explanations, rooted in market segmentation or access limitations. However, we can also make sense of this pattern in the data by considering the quanto risk inherent in the two instruments. As I show below, the correlation of default risk and the value of the local currency, which may well be more substantial for firms in emerging markets rather than those in developed markets, can lead to differences in bond prices, and hence yields, between two assets that may at first glance look interchangeable. While cash flows of the two instruments (in the presented simplified form) are identical in the case of repayment, if the firm defaults, the investor in the local currency bond still owns the currency forward contract. Intuitively, since the investor is now overhedged, due to the reduction or complete loss of bond redemptions, the currency forward provides additional value. Since the forward contract allows the purchase of a fixed amount of US Dollars for a pre-determined amount of the local currency, if the local currency tends to depreciate concurrently with firm default, the forward contract provides a hedge. As a result, the two instruments may have different prices, even under the assumption of frictionless markets and no-arbitrage.

Based on Du and Schreger (2016), I consider the pricing of the two bond instruments from the perspective of a risk-neutral US Dollar-based investor, under the assumption of frictionless capital markets and no-arbitrage. For simplicity, I consider a one-period bond, with a probability of default D, which is the same for both bonds, and zero recovery in default. We can write the price P of the Dollar-denominated bond as

$$P_{i,t}^{\$} = exp(-r_t^{\$})\mathbb{E}(1 - D_{i,t+1}), \tag{14}$$

where $r^{\$}$ denotes the risk-free rate in US Dollars. Similarly, we can write the price of the bond denominated in currency j as

$$\frac{P_{i,t}^{j}}{S_t} = exp(-r_t^{\$})\mathbb{E}\left(\frac{1 - D_{i,t+1}}{S_{t+1}}\right), \tag{15}$$

where S denotes the nominal exchange rate between currency j and the Dollar, i.e. the number of units of currency j necessary to purchase a Dollar. Under the assumption that uncovered interest rate parity holds, we can replace the expected change in the exchange rate with the forward premium priced in forward markets, i.e.

$$\frac{F_t}{S_t} = \mathbb{E}\left(\frac{S_{t+1}}{S_t}\right), \tag{16}$$

where F denotes the current forward contract on the exchange rate in the next period. Under covered interest rate parity, we can then uncover the risk-free interest rate in currency j,

$$exp(-r_t^{\$})\left(\frac{S_t}{F_t}\right) = exp(-r_t^{j}). \tag{17}$$

We can rewrite the price of the local currency bond as

$$P_{i,t}^{j} = exp(-r_t^{j})\mathbb{E}(1 - D_{i,t+1})\left[1 + \frac{Cov\left(1 - D_{i,t+1}, \frac{S_t}{S_{t+1}}\right)}{\mathbb{E}(1 - D_{i,t+1})\mathbb{E}\left(\frac{S_t}{S_{t+1}}\right)}\right]. \tag{18}$$

Using (15), we can immediately see that the price on the local currency bond, hedged back into US

Dollar, will only be equal to the price of the Dollar-denominated bond if the covariance of corporate default and the exchange rate is zero, i.e.

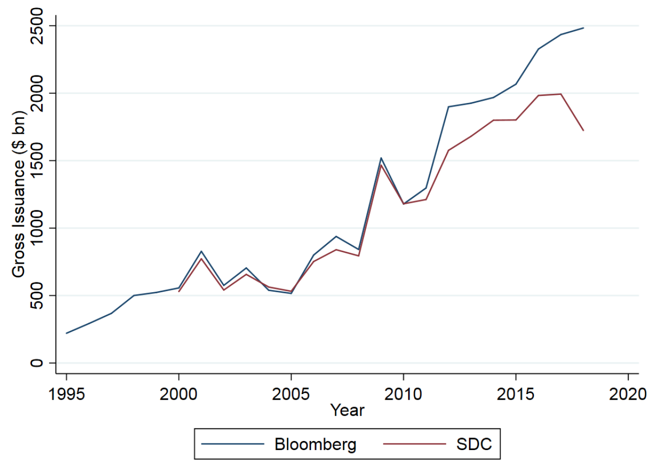
$$P_{i,t}^{\$} = \frac{F_t}{S_t} P_{i,t}^{j} \qquad if \quad Cov\left(1 - D_{i,t+1}, \frac{S_t}{S_{t+1}}\right) = 0. \tag{19}$$

In turn, if the covariance between the local currency and corporate default is positive, i.e. the local currency depreciates (the units necessary to purchase a dollar increases $S + t + 1 \uparrow$) at the same time as the firm defaults, then, the price on the currency-hedged local currency bond will be higher than the price of the Dollar-denominated bond:

$$P_{i,t}^{\$} < \frac{F_t}{S_t} P_{i,t}^{j} \qquad if \quad Cov\left(1 - D_{i,t+1}, \frac{S_t}{S_{t+1}}\right) > 0. \tag{20}$$

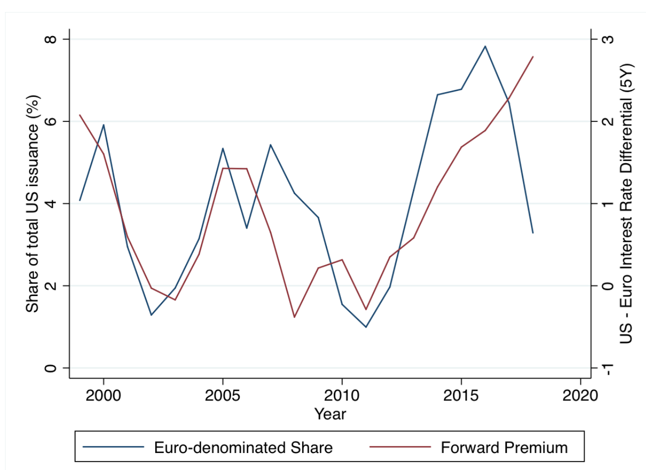
Since a higher bond price implies a lower yield, this replicates the observation in the data.

Figure 1-A1: Total gross issuance volume coverage in Bloomberg Back Office



Notes: This chart shows the total annual gross issuance of non-financial private sector companies captured in the data set underlying this paper (Bloomberg), and the figures from a similar data set constructed based on the data from the SDC Platinum database in Celik et al. (2019). The data set from Celik et al. (2019) starts in 2000.

Figure 1-A2: Issuance behavior of US non-financial firms and relative interest rates



Notes: This figure shows the share of total gross bond issuance by US non-financial firms that is denominated in Euro, against the US-Euro interest rate differential (measured as the 5-year forward premium). A positive interest rate differential indicates that US interest rates are higher than Euro interest rates.

Table 1-A1: Firm characteristics of single- and multi-currency issuers

	All Issuers	Multi-currency Issuers
Firm-Year observation	39,681	3,050
# of bonds issued (mean)	2.24	6.44
# of currencies issued in (mean)	1.12	2.51
Total issuance (mean, $ bn)	0.59	2.29

Table 1-A2: Pass-through of risk-free interest rate differentials to corporate bond yields by duration

	$y_{i,t}^{j,d} - r_t^{\$,d}$					
	(1)	(2)	(3)	(4)	(5)	(6)
$r_t^{j,d} - r_t^{\$,d}$	0.992***	0.997***	1.101***	1.123***	1.113***	0.848***
	(0.039)	(0.075)	(0.124)	(0.041)	(0.045)	(0.140)
N	10200	12699	10130	11930	4740	3032
R^2	0.71	0.67	0.71	0.79	0.82	0.59
Maturity-Year FE	Y	Y	Y	Y	Y	Y
Duration	≤3	(3,5]	(5,7]	(7,10]	(10-15]	>15

SEs in parantheses, clustered by country. *p<0.1, **p<0.05, ***p<0.01

Notes: Risk-free interest rate differentials are measured using currency forward premia and currency swaps (Du and Schreger, 2016), and match the underlying corporate bond's duration. Each column shows different subsamples by bond duration. Data runs from 1995 to 2019.

Table 1-A3: Pass-through of risk-free interest rate differentials to corporate bond borrowing costs in common currency by duration

	$y_{i,t}^{j,d} - r_t^{\$,d} + \Delta s_{t+d}^{j,d}$					
	(1)	(2)	(3)	(4)	(5)	(6)
$r_t^{j,d} - r_t^{\$,d}$	0.427	0.747***	0.754***	0.562***	0.705***	0.159
	(0.282)	(0.133)	(0.198)	(0.074)	(0.082)	(0.209)
N	9303	10769	7970	9086	3786	2189
R^2	0.46	0.34	0.56	0.62	0.68	0.54
Maturity-Year FE	Y	Y	Y	Y	Y	Y
Duration	≤3	(3,5]	(5,7]	(7,10]	(10-15]	>15

SEs in parantheses, clustered by country. *p<0.1, **p<0.05, ***p<0.01

Notes: Effective borrowing cost in common currency is calculated as the yield to maturity of each bond, plus the appreciation in the issuance currency's nominal exchange rate relative to the US Dollar, annualized over the duration of the bond. Risk-free interest rate differentials are measured using currency forward premia and currency swaps (Du and Schreger, 2016), and match the underlying corporate bond's duration. Each column shows different subsamples by bond duration. Data runs from 1995 to 2019.

Table 1-A4: Pass-through of risk-free interest rate differentials to corporate bond yields by duration with firm-year fixed effects

	$y_{i,t}^{j,d} - r_t^{\$,d}$					
	(1)	(2)	(3)	(4)	(5)	(6)
$r_t^{j,d} - r_t^{\$,d}$	0.836***	0.894***	0.926***	0.984***	1.099***	0.766***
	(0.063)	(0.032)	(0.079)	(0.031)	(0.069)	(0.241)
N	1811	1990	1075	1671	712	311
R^2	0.94	0.96	0.96	0.95	0.90	0.70
Maturity-Year FE	Y	Y	Y	Y	Y	Y
Firm-Year FE	Y	Y	Y	Y	Y	Y
Duration	≤3	(3,5]	(5,7]	(7,10]	(10-15]	>15

SEs in parantheses, clustered by country. *p<0.1, **p<0.05, ***p<0.01

Notes: Risk-free interest rate differentials are measured using currency forward premia and currency swaps (Du and Schreger, 2016), and match the underlying corporate bond's duration. Each column shows different subsamples by bond duration. Data runs from 1995 to 2019.

Table 1-A5: Pass-through of risk-free interest rate differentials to corporate bond borrowing costs in common currency by duration with firm-year fixed effects

	$y_{i,t}^{j,d} - r_t^{\$,d} + \Delta s_{t+d}^{j,d}$					
	(1)	(2)	(3)	(4)	(5)	(6)
$r_t^{j,d} - r_t^{\$,d}$	0.425**	0.721***	0.738**	0.549**	0.487	-0.497*
	(0.172)	(0.148)	(0.263)	(0.239)	(0.384)	(0.224)
N	1721	1665	706	1020	446	202
R^2	0.70	0.65	0.78	0.71	0.71	0.70
Maturity-Year FE	Y	Y	Y	Y	Y	Y
Firm-Year FE	Y	Y	Y	Y	Y	Y
Duration	≤3	(3,5]	(5,7]	(7,10]	(10-15]	>15

SEs in parantheses, clustered by country. *p<0.1, **p<0.05, ***p<0.01

Notes: Effective borrowing cost in common currency is calculated as the yield to maturity of each bond, plus the appreciation in the issuance currency's nominal exchange rate relative to the US Dollar, annualized over the duration of the bond. Risk-free interest rate differentials are measured using currency forward premia and currency swaps (Du and Schreger, 2016), and match the underlying corporate bond's duration. Each column shows different subsamples by bond duration. Data runs from 1995 to 2019.

Table 1-A6: Pass-through of risk-free interest rate differentials to corporate bond yields, matched on bond maturity

	$y_{i,t}^{j,d} - r_t^{\$,d}$		
	(1)	(2)	(3)
$r_t^{j,d} - r_t^{\$,d}$	1.049***	0.889***	0.792***
	(0.059)	(0.053)	(0.101)
N	31897	31757	39552
R^2	0.69	0.74	0.90
Maturity-Year FE	Y	Y	Y
Sector-Year FE	Y		
Country-Year FE		Y	
Firm-Year FE			Y

SEs in parantheses, clustered by country. *p<0.1, **p<0.05, ***p<0.01

Notes: Risk-free interest rate differentials are measured using currency forward premia and currency swaps (Du and Schreger, 2016), and match the underlying corporate bond's time to maturity. Data runs from 1995 to 2019.

Table 1-A7: Pass-through of risk-free interest rate differentials to corporate bond yields by bond type

	$y_{i,t}^{j,d} - r_t^{\$,d}$			
	(1)	(2)	(3)	(4)
$r_t^{j,d} - r_t^{\$,d}$	0.840***	0.725***	0.895***	0.935***
	(0.069)	(0.152)	(0.063)	(0.010)
N	29320	18273	17699	13494
R^2	0.94	0.95	0.85	0.91
Maturity-Year FE	Y	Y	Y	Y
Firm-Year FE	Y	Y	Y	Y
Bond Sample	Non-callable	Senior Unsecured	Large Issue	Non-Domestic

SEs in parantheses, clustered by country. *p<0.1, **p<0.05, ***p<0.01

Notes: Risk-free interest rate differentials are measured using currency forward premia and currency swaps (Du and Schreger, 2016), and match the underlying corporate bond's duration. Each column shows different subsamples by bond characteristic. The first column includes only bonds that are not callable. The second column includes only bond instruments of "senior unsecured" status. Column 3 only includes bonds with issue amounts above the sample median (USD 130 million). Column 4 only uses bonds whose market of issuance is Non-Domestic, i.e. "Eurobonds" or "Global" bond issues. Data runs from 1995 to 2019.

Table 1-A8: Pass-through of risk-free interest rate differentials to firm-level cost of capital by characteristics

	$\overline{ROA}_{i,t+5}$			
	Large Firms	High Leverage	High Int'l Sales	Emerging Markets
	(1)	(2)	(3)	(4)
$r_t^j - r_t^\$$	0.390***	0.383***	0.448***	0.605***
	(0.100)	(0.073)	(0.085)	(0.111)
$(r_t^j - r_t^\$) \cdot \mathbb{I}_{i,t}^{group}$	0.092	-0.089	-0.099	-0.416*
	(0.113)	(0.073)	(0.155)	(0.241)
N	8702	8702	8185	8703
R^2	0.24	0.24	0.25	0.24
Sector-Year FE	Y	Y	Y	Y

SEs in parantheses, clustered by country. *p<0.1, **p<0.05, ***p<0.01

Notes: Firm ROA is measured as the ratio of firm earnings (EBITDA) to total assets over the next five years. Risk-free interest rate differentials are measured using currency forward premia at the 1-year maturity point. Firm size is measured as the log of firm total assets in USD, all other firm characteristics are calculated as ratios to firm assets or sales. All firm information is contemporaneous to bond issuance. The second row captures the coefficient on the forward premium added a second time, interacted with a dummy variable that is equal to one if the underlying firm is above the sample median for firm size, leverage, or international sales exposure. The last column proceeds similarly, with the interaction being equal to one if the firm's underlying country of risk exposure is considered an emerging market by the IMF. Data runs from 1995 to 2019.

Table 1-A9: Pass-through of risk-free interest rate differentials to firm-level return on assets (ROA): alternative measures

	$\frac{Net\ Income}{Total\ Assets}$	$\frac{Net\ Income\ (pre\ tax)}{Total\ Assets}$	$\frac{EBIT}{Total\ Assets}$	$\frac{EBITDA}{PPE}$	ROE
	(1)	(2)	(3)	(4)	(5)
$r_t^{j,d} - r_t^{\$,d}$	0.332***	0.373***	0.471***	2.016***	1.05***
	(0.099)	(0.128)	(0.142)	(0.672)	(0.167)
N	8748	8712	8769	8241	8365
R^2	0.18	0.19	0.22	0.31	0.17
Sector-Year FE	Y	Y	Y	Y	Y

SEs in parantheses, clustered by country. *p<0.1, **p<0.05, ***p<0.01

Notes: Firm ROA is measured as the ratio of firm earnings to total assets over the next five years, with each column using an alternative means of construction. All measures are computed using contemporaneous values for numerator and denominator, and as the average over the next five years. EBIT denotes Earnings Before Interest and Taxes. PPE denotes the total value of firm physical assets, measured as property, plants and equipment. ROE describes firm return on equity, calculated as net income over book equity, also over the next five years. Risk-free interest rate differentials are measured using currency forward premia at the 1-year maturity point, and firms are assigned the forward premium of their domestic currency, based on the ultimate parent company's country of risk designation in Bloomberg. Data runs from 1995 to 2019.

Table 1-A10: Pass-through of risk-free interest rate differentials to firm-level return on assets (ROA): alternative time frames

	$ROA_{i,t}$	$ROA_{i,t+1}$
	(1)	(2)
$r_t^j - r_t^\$$	0.395***	0.414***
	(0.145)	(0.157)
N	12142	12119
R^2	0.12	0.19
Sector-Year FE	Y	Y

SEs in parantheses, clustered by country. *p<0.1, **p<0.05, ***p<0.01

Notes: Firm ROA is measured as the ratio of firm earnings (EBITDA) to total assets. Column 1 computes the ratio based on contemporaneous data, while column 2 uses data for the following year (both for denominator and numerator). Risk-free interest rate differentials are measured using currency forward premia at the 1-year maturity point, and firms are assigned the forward premium of their domestic currency, based on the ultimate parent company's country of risk designation in Bloomberg. Data runs from 1995 to 2019.

Table 1-A11: Pass-through of risk-free interest rate differentials to firm-level return on assets (ROA): firm fixed effects and non-issuance years

	$\overline{ROA}_{i,t+5}$			
	(1)	(2)	(3)	(4)
$r_t^j - r_t^\$$	0.179***	0.145***	0.295*	0.174***
	(0.061)	(0.032)	(0.148)	(0.043)
N	8735	7344	32940	32645
R^2	0.30	0.87	0.08	0.67
Sector-Year FE	Y	Y	Y	Y
Country FE	Y			
Incl. non-issuance years			Y	Y
Firm FE		Y		Y

SEs in parantheses, clustered by country. *p<0.1, **p<0.05, ***p<0.01

Notes: Firm ROA is measured as the ratio of firm earnings (EBITDA) to total assets, on average over the next five years. Column 1 adds a country fixed effect to the standard regression. Column 2 and 4 include firm-level fixed effects, while columns 3 and 4 expands the sample to include data from non-issuance years for all firms in the bond market data set. Risk-free interest rate differentials are measured using currency forward premia at the 1-year maturity point, and firms are assigned the forward premium of their domestic currency, based on the ultimate parent company's country of risk designation in Bloomberg. Data runs from 1995 to 2019.

Table 1-A12: Pass-through of risk-free interest rate differentials to firm-level return on assets (ROA): alternative interest rate maturities

	$\overline{ROA}_{i,t+5}$		
	3Y Fwd Prem	5Y Fwd Prem	10Y Fwd Prem
	(1)	(2)	(3)
$r_t^{j,d} - r_t^{\$,d}$	0.498***	0.531***	0.586***
	(0.133)	(0.133)	(0.137)
N	8745	8758	8714
R^2	0.24	0.24	0.25
Sector-Year FE	Y	Y	Y

SEs in parantheses, clustered by country. *p<0.1, **p<0.05, ***p<0.01

Notes: Firm ROA is measured as the ratio of firm earnings (EBITDA) to total assets, on average over the next five years. Risk-free interest rate differentials are measured using currency forward premia at the 3-, 5-, and 10-year maturity point, respectively in each column, and firms are assigned the forward premium of their domestic currency, based on the ultimate parent company's country of risk designation in Bloomberg. Data runs from 1995 to 2019.

Table 1-A13: Pass-through of realized UIP violations to firm-level return on assets (ROA)

	$\overline{ROA}_{i,t+5}$
	(1)
$(r_t^{j,5} - r_t^{\$,5}) + (s_{t+5}^j - s_t^j)^{\frac{1}{5}}$	0.215**
	(0.093)
N	8462
R^2	0.22
Sector-Year FE	Y

SEs in parantheses, clustered by country. *p<0.1, **p<0.05, ***p<0.01

Notes: Firm ROA is measured as the ratio of firm earnings (EBITDA) to total assets, on average over the next five years. Realized UIP violations are calculated as the 5-year forward premium of the firm's local currency to the US Dollar, plus the annualized change in the nominal exchange rate over the following 5 years, contemporaneous the time window used to compute ROA. Data runs from 1995 to 2019.

Table 1-A14: Pass-through of risk-free interest rate differentials to firm-level return on assets (ROA): original country designation

	$\overline{ROA}_{i,t+5}$	
	(1)	(2)
$r_t^j - r_t^{\$}$	0.392**	0.536***
	(0.087)	(0.089)
$\left(r_t^j - r_t^{\$}\right) \mathbb{I}_{i,t}^{FC}$		-0.355**
		(0.145)
N	8503	8503
R^2	0.23	0.23
Sector-Year FE	Y	Y

SEs in parantheses, clustered by country. *p<0.1, **p<0.05, ***p<0.01

Notes: Firm ROA is measured as the ratio of firm earnings (EBITDA) to total assets, on average over the next five years. Risk-free interest rate differentials are measured using currency forward premia at the 1-year maturity point, and firms are assigned the forward premium of their domestic currency, based on the underlying firm's primary country of domicile, not the country of the ultimate parent company. The second row interacts the forward premium with a dummy variable, equal to 1 if the firm issues bonds in foreign currency in a given year. Data runs from 1995 to 2019.

Table 1-A15: Alternative standard errors

	Bond yield	$\overline{ROA}$
Panel A: Analytical		
Robust	0.006	0.031
Cluster by year	0.026	0.060
Cluster by country*	0.068	0.153
Cluster by country and year	0.069	0.151
Cluster by industry	0.018	0.087
Cluster by industry and year	0.029	0.096
Panel B: Bootstrap		
Robust	0.006	0.028
Cluster by year	0.105	0.202
Cluster by country	0.026	0.060
Cluster by country and year	0.006	0.029

Notes: This table shows the various standard errors on the Forward Premium variable $r_{i,t}^{j,d} - r_{i,t}^{\$,d}$ in the standard specification for the bond yield regression (column 1 in table 3), and the firm ROA regression (column 1 in table 5). The bootstrapped standard errors in Panel B are obtained using 1,000 draws with replacement. * denotes the standard specification.

CHAPTER TWO

International Portfolio Holdings and Return Differentials *

Julian Richers †

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Abstract

This paper examines the relationship of international portfolio holdings and asset returns. When foreigners own fewer assets in a particular country, currency returns, interest rates and stock returns are all higher. This finding establishes a connection between two major puzzles in the literature, the carry trade and portfolio home bias, that have mostly been studied in isolation. Measures of capital market accessibility can jointly explain empirical variation in foreign ownership rates and return differentials. A portfolio strategy motivated by market accessibility gives rise to an "improved" carry trade strategy, with higher Sharpe ratios and lower downside risks, both in currencies and equities. Motivated by the finding that countries with lower levels of financial integration also have a stronger link between consumption and domestic output dynamics, I develop an international asset pricing model with agency frictions. This gives rise to a simple mechanism: When frictions constrain the amount of local assets that foreigners can hold, local investors are limited in their ability to diversify internationally. These limits give rise to risk premia that align with the severity of the friction, matching the patterns documented in the data. This mechanism suggests a new fundamental explanation for the existence of the carry trade, rooted in limited financial integration, and highlights a new perspective on gross cross-border asset holdings.

1 Introduction

This paper documents a new connection between two major puzzles in international finance, the carry trade and portfolio home bias. The former describes a simple but surprisingly profitable investment strategy, where investors lend (go long) in currencies of high-interest rate countries, and borrow (go short) in currencies of low-interst rate ones (Lustig, Roussanov and Verdelhan, 2011). It is one of the most enduringly popular strategies for professional investors and symptomatic of the more broadly existing differences in asset returns across countries. In comparison, portfolio home bias (Coeurdacier and Rey, 2013) describes the observation that investors generally favor assets in their home country, and are less willing to invest in foreign countries.[1] Given that investing in international assets theoretically stand to provide diversification benefits, the fact that cross-border asset holdings are not larger is a puzzling feature of international asset markets.

Even if not directly related at first sight, these two puzzles arguably describe two sides of the same coin: while the carry trade deals with the price side of international financial markets, the home bias considers the quantity side. However, most of the literature treats these puzzles separately. The home bias literature has emphasized the role of frictions to capital mobility, such as transaction and information costs, or those rooted in institutional imperfections. In turn, explanations for return differentials have generally been rooted in risk. Models with complete asset markets have focused on countries' differential exposure to global risk (Hassan (2013), Richmond (2018) and others), while models in incomplete market settings identify the risk exposure of intermediaries necessary to manage net capital flow imbalances (Gabaix and Maggiori, 2015).

In this paper, I explore the connection between prices and quantities, and document a new empirical fact: In a broad dataset of developed and emerging market economies, I show that when foreigners own more domestic assets (i.e. claims on the local economy), returns on currencies and equities (in aggregate and in the non-traded relative to the traded sector) are all lower, as are interest rates (Table 1). This relationship is a puzzle from the perspective of most models for return differentials. Under complete markets, higher returns indicate stronger exposure to global - undiversifiable - risk. But this alignment of foreign ownership and returns would imply that countries with the strongest global risk exposure are also least globally diversified. Under the assumption that foreigners should have less exposure to individual country risk than locals, this generates the question

[1] Or, as shown by Maggiori, Neiman and Schreger (2018), in assets denominated in foreign currencies.

why foreigners do not allocate more funds towards high-return countries.

In line with popular explanations of home bias, I consider the role of financial frictions. There are already models of return differentials that incorporate financial shocks, such as Itskhoki and Mukhin (2017), or other models that emphasize the role of intermediaries (Gabaix and Maggiori, 2015). However, these mechanisms are likely to be insufficient to explain this new set of facts, as I find that gross portfolio holdings have explanatory power for asset prices above and beyond net imbalances.[2]

Instead, I study the importance of capital market institutions and limits to global financial integration. I show that countries where a relatively smaller part of the domestic stock market is considered "investable" for international investors, foreign ownership is lower, *and* returns are higher. This holds even for assets that are clearly internationally accessible. I show that the investable share of a domestic stock market can be thought of as a measure of insider ownership requirements, which is indicative of corporate level agency frictions. This is consistent with previous work showing that variation in agency costs can matter for firm cost of capital and asset returns (Stulz, 2005), and for foreign investor asset holdings (Leuz et al., 2010). However, while it is intuitive that difficult to access markets might provide higher returns, it is not clear why frictions in one part of the economy should matter for assets that are not directly exposed to them. The most salient example here are currency forwards. Why should returns on forward contracts, an instrument traded most frequently with global broker-dealers in London or New York, be systematically related to capital (equity) market frictions in the local economy?

I show that these findings have substantial economic implications. Using a portfolio sorting approach, I find that an investment strategy based on cross-country variation in fundamental agency frictions shows strong similarities with the traditional carry trade in currencies, but with a noticeably better Sharpe ratio and lower downside risk, as measured by maximum drawdown and skew. In addition, two observations set the new strategy apart from the standard carry trade: First, while currency carry trades have not worked consistently well since the 2008 financial crisis, the new strategy has continued to deliver strong returns. Second, applying the currency carry trade methodology to other assets, such as sorting stock indices on differences in local risk-free interest rate differentials, has not been profitable.[3] In contrast, I show that the investable share is a strong

[2] I.e. those capital flows that might arguably require to be intermediated by financial institutions with constrained balance sheets.

[3] Koijen et al. (2019) show that asset class-specific measures for carry lead to profitable strategies, including in

axis of differentiation for stock returns as well as currencies. The factor structure of asset returns suggests firstly, that the carry trade consists at least in part of taking advantage of different levels of financial integration across countries, and second, that these differences have large effects, as measured by asset returns.

What drivers are behind the connection between return differentials and limits to international financial integration? I find that countries with lower foreign ownership shares have a stronger link between local real consumption and domestic output growth, even when accounting for global cyclical trends. This finding provides evidence that limits to financial integration affect the extent to which residents of a country can share risk, and insure against local shocks, in international markets. Based on this insight, I turn to a simple international asset pricing model. Starting with the standard Backus Smith (1993) baseline, I add an agency friction and heterogeneous investor types, which gives rise to a simple mechanism: When agency frictions limit foreign ownership of domestic assets, local households are forced to hold a portfolio that is weighted towards domestic assets, generating home bias. As a result, domestic agents are imperfectly diversified and more heavily exposed to local risk. If the local agent prices the asset, this gives rise to local risk premia in a broad selection of assets, including currencies and interest rates where the agency friction has no direct relevance, matching the empirical findings.

In comparison to previous fundamental explanations of return differentials, this paper adds to the literature by being able to connect variation in asset quantities with asset prices. Furthermore, it suggests that (parts of) international variation in returns can be traced back to frictions in international risk sharing, and that gross international capital stocks and flows can play a significant role above and beyond the most-commonly studied behavior of net flows.

The paper proceeds as follows: I discuss the relevant literature in section 2. Section 3 describes the data, empirical strategy and results, both regarding gross capital positions and the more fundamental role of agency frictions. Section 4 outlines the theoretical model, and section 5 discusses its implications. Section 6 concludes.

equities, but as I show in this paper, the standard measure of carry in currencies is not a transferable to equities.

2 Literature

From the perspective of standard international finance models, the carry trade describes two phenomena: first, the existence of persistent interest rate differentials, both real and nominal, and second, the failure of uncovered interest rate parity (UIP). While both of these features have been studied for quite some time, in more recent years an active literature has explored country asymmetries as the cause for the profitability of the carry trade. Differences in "unconditional" currency returns arise from variations of the stochastic properties of exchange rates: High interest rate currencies tend depreciate when global conditions worsen (Lustig, Roussanov and Verdelhan, 2011). Country size (Hassan, 2013), trade centrality (Richmond, 2018), factor endowments (Ready, Roussanov and Ward, 2015) and disaster risk (Farhi and Gabaix, 2015) have all been identified as fundamental drivers of cross-country variation in global risk exposure, giving rise to systematic currency premia.

An important fundamental assumption shared by all these papers is that of complete financial markets. This gives rise to a single, global pricing kernel that prices all assets purely based on their stochastic properties vis-a-vis global shocks. In contrast, this paper establishes a new set of empirical facts that is difficult to reconcile with the complete market assumption: I document a systematic relationship between international return and interest rate differentials on the one hand, and gross international asset positions on the other. Since in complete markets, relative portfolio allocations are irrelevant (as all idiosyncratic risk is hedged away), this particular empirical regularity does not fit the standard approach of studying international return differentials.

In this way, this paper is closely related to Gabaix and Maggiori (2015), who study return differentials in a theoretical model with incomplete markets. Incomplete, intermediated markets mean that net imbalances, i.e. a country being a net lender or borrower in international capital markets, can drive carry trade returns. This paper suggests a different (though not competing) mechanism because I show how variation in gross portfolio postions matters for asset returns, in absence of (or after controlling for) net balances. As a result, this paper builds a bridge between the study of return differentials and the extensive literature on international portfolio allocation.

In this string of the literature, home bias describes the tendency for investment portfolios to be heavily weighted towards the investor's country (or even region) of residence in practice. Researchers have proposed different drivers for this apparent failure of efficient portfolio management in an international context, ranging from transaction costs to information frictions or behavioral biases (see Coeurdacier and Rey (2012) for a thorough discussion).[4] But, perhaps more fundamentally, the data also show that barriers to foreign asset ownership are not uniform across countries. In the following, I show that variation in the extent of cross-broder asset holdings (and the strenght of these frictions) is systematically related to asset returns, and how both of these features can be explained by said barriers in a simple model. In its focus on corporate-level frictions as a factor in international capital allocation, the paper relates closely to Lins et al. (2010), who find that foreigners invest substantially less in firms with weaker corporate governance, i.e. when agency problems are stronger. Similarly, Kho, Stulz and Warnock (2009) argue that agency frictions directly connect to portfolio home bias by restricting the share of assets actually available to international investors - an intuition I incorporate as well.

Along the way, the paper builds on previous empirical and theoretical insights into the structure of gross global capital flows and asset holdings. First, Bluedorn et al. (2013) show that gross capital flows are largely offsetting, i.e. that higher gross capital inflows into a country (such as domestic asset purchases by foreigners) coincide with an increase in gross capital outflows (foreign asset purchases by locals). As a result, gross capital flows are substantially larger than net flows that have received wide attention in previous work. In related work, Caballero and Simsek (2018) highlight the diversification benefits that cross-border offsetting gross portfolio positions can provide, but do not consider exchange rates. Second, as documented in Gourinchas and Rey (2007) the gross portfolio positions of the US show a marked asymmetry between assets and liabilities: US investors hold disproportionately more risky foreign assets, such as equities, while liabilities to foreign investors primarily consist of safer US assets (debt/bond securities). Maggiori (2017) shows how differences in financial development give rise to said country balance sheet asymmetry and how this may affect the safe-haven status of the US Dollar. In the theoretical section, I use the previously established evidence to motivate financial market segmentation.

Studying exchange rates and international asset prices in incomplete markets setttings is not a new endeavor. Alvarez, Atkeson and Kehoe (2002), Pavlova and Rigobon (2010, 2012) and Lustig and Verdelhan (2018) are just a small selection of the literature that studies models where investors

[4] An alternative explanation for the portfolio home bias has been that it might be optimal after all - given the right mix of undiversifiable income risk and substitutability of traded and non-traded goods, such as in Cole and Obstfeld (1991) and Heathcote and Perri (2013). But while these models show how home bias might not be as much of a puzzle as one might think by looking at the data, they do not provide an explanation for the connection between home bias and return differentials, much less a link to observed market accessibility frictions, both of which are at the heart of this paper.

face an incomplete set of international assets for purchase. [5] The innovation in this paper is that I explicitly study the role of asset quantity constraints, which generates home bias: Global investors are limited in how large a share of the domestic market they can own, which turns the local investor into the marginal buyer. The quantity friction determines the extent of the local agent's diversification, which drives return differentials.

Due to this reliance on an agency friction to limit foreign ownership of domestic assets, my paper connects to another rich literature on the confluences of country characteristics and corporate finance: La Porta et al. (1999) is representative of the extensive work done on the interaction of variations in local legal systems and corporate structures. As discussed above, Stultz (2005) and Himmelberg et al. (2004) both discuss the role of insider ownership requirements in determining asset returns, or the cost of capital. Albuquerque and Wang (2008) show that imperfect investor protection can have far-reaching asset pricing implications but do not consider exchange rates or international capital flows. This paper adds to this literature as it shows how, through equilibrium effects, agency frictions in one particular market can have drive return differentials even in assets where the friction is not directly present.

3 Empirical Analysis

In this section, I document that cross-border gross portfolio holdings have predictive content for international asset return differentials. In particular, the analysis highlights four key empirical regularities:

1. Countries with higher foreign ownership shares pay lower average currency premia (excess bond returns in USD).

2. Countries with higher foreign ownership shares have lower risk-free interest rates (lower forward premia).

3. Countries with higher foreign ownership shares have lower aggregate stock market returns.

4. Countries with higher foreign ownership shares have a lower spread between returns on stocks in the non-traded sector and those in the traded sector.

[5] Other work, such as Itskhoki and Mukhin (2017) and Corsetti, Dedola and Leduc (2008), show how further assumptions on price setting and trade elasticity in combination with financial shocks and incomplete markets can explain a number of puzzles in the exchange rate literature.

In a second step, I show that constraints on capital market accessibility, in particular those that can be traced back to corporate-level agency frictions, can explain variation in foreign ownership levels across countries. Using an instrumental variable regression, I then show that variation in foreign ownership related to capital market frictions has strong asset pricing properties on its own, confirming - and sharpening - the above set of results.

Lastly, following the literature on return anomalies, I show that using foreign ownership and agency frictionsas a portfolio sorting variables give rise to profitable investment strategies. Going further, portfolio factors constructed using the cross-asset portfolios (currencies and equities) based on agency frictions have very strong asset pricing properties, and are equally if not more profitable than the traditional carry trade.

3.1 Data

My dataset consists of 26 countries with quarterly data from 2001 to 2019.[6] The dataset deliberately includes developed and emerging markets in order to capture a broader range of the independent variable, foreign investor ownership of domestic assets, but also because, after the introduction of the Euro in 1999, the sample of developed markets with their own currency shrinks dramatically. The emerging economies included in my sample are generally considered accessible to international investors, as indicated by their inclusion in the MSCI EM Index, a broad, widely followed emerging market stock index, and have floating exchange rate, at least for part of the sample.

I treat the data as a series of cross-sections while controlling for time-fixed effects and calculating heteroskedasticity-robust standard errors, clustered at the country-level. For asset returns, I take the perspective of a global investor and calculate excess returns in USD. This calculation also takes care of possible inflation differentials between countries driving return differentials in local currency, and I make other adjustments in case this does not apply.

My preferred measure of foreign ownership of domestic assets is total portfolio liabilities to foreigners, as collected in the IMF Coordinated Portfolio Investment Survey (CPIS) database. While data on cross-broder portfolio flows and stocks struggle with a number of measurement issues, the CPIS constructs a country's liabilities by surveying each country's holdings of securities issued by issuers, public and private, located in a foreign country. For each country, we can then add up

[6] In some instances, for example in some robustness regressions (see appendix), data is available further back in time.

all claims held by foreigners against it, which generates a synthetic measure of a country's foreign liabilities.[7] My preferred independent variable for a specific country is hence defined as:

$$Q = \frac{\textit{Equity Portfolio Liabilities} + \textit{Debt Security Portfolio Liabilities}}{GDP}, \tag{1}$$

where GDP is the country's Gross Domestic Product in US Dollars from the IMF IFS database, and Equity and Debt Security liabilities are the respective USD figures reported in the CPIS, with interpolated values if applicable.[8] Figure 1 shows the time series of foreign ownership of domestic Australian assets as an example, where the red line describes the data updated with Balance of Payments (BOP) flows, and blue the original annual data.[9]

Table A1 in the appendix gives summary statistics for all the major variables in my sample. For foreign ownership, the variable varies between less than 10% of GDP for countries such as Chile in 2001 up to around 100% for the United Kingdom and Switzerland. I drop countries for time periods during which they follow a nominal exchange rate peg to the USD.[10] On average, foreigners own about 45% of GDP worth of domestic assets, with a standard deviation of 33%. [11]

The set of dependent variables are log quarterly excess asset returns from the perspective of a US investor, unless noted otherwise. Based on exchange rates and equity market data from Thomson Reuters Datastream, I calculate international bond (or currency) returns of country j as the USD return on currency forward contracts with a 3-month maturity:

$$r^j_{t+1} = f^j_t - s^j_{t+1}, \tag{2}$$

[7]Given that it is easier to reliabily survey asset owners rather than issuers about final ownership, this measure can be considered to be a more accurate measure than the International Investment Position data (IIP), also collected by the IMF. As I discuss below, my results are robust to using IIP data (both for assets and liabilities, portfolio and total). While the CPIS provides arguably the most comprehensive overview of a country's international liabilities, it comes with two limitations. First, data collection only begins in 2001, which limits my sample. Second, there is no aggregate value collected for the Euro area (I can however include it for regressions using the IIP).

[8]To increase the frequency of the variable, which is first only available yearly, and later on, bi-annually, I interpolate the year-end CPIS data with gross portfolio inflows from the IMF's BPM6 database.

[9]Since gross cross-border asset holdings have generally increased since the beginning of the sample, in particular during the 2000s, one might be worried about non-stationarity in the foreign ownership measure. In the regression setting, time-fixed effects take care of aggregate trends, and the results are robust to using a re-scaled variable of foreign ownership that standardizes total foreign liabilities of all countries in the sample to 1 in each period. Furthermore, controlling for country-specific trends (forced to sum to 0 across time) also does not alter the results.

[10]I consider a currency pegged if, over the last year, there has not been a single monthly change in the nominal exchange rate to the USD of 1 percent or more in absolute value.

[11]In general, weighting foreign portfolio ownership by GDP is not directly compatible with the model. One would prefer a measure of the share that foreigners hold of all claims on domestic output, which would require an adjustment by valuation levels (through something like a price-earnings ratio, for example). Because of the broad set of assets aggregated in this data (public and private securities, long and short duration assets, and so forth), I rely on the imperfect but consistent scaling using GDP.

where s^j_{t+1} is the log spot exchange rate between foreign currency j and the USD at time $t+1$ (one quarter ahead), while f^j_t is the 3-month log forward exchange rate at time t. Under covered interest rate parity (CIP), the return on this trade is equal to the difference of the nominal interest rates in country j and the US, plus the realized change in the nominal exchange rate. I also make use of forward premia rather than the differential between sovereign bills or interbank rates since the latter measures may incorporate default risk. While forward premia might also incorporate counterparty risk, those are on the side of the currency market intermediary, such as a global bank or broker-dealer, rather than on the individual country under study. Hassan (2013) shows that at least for a subset of currencies where default-free currency futures contracts are available, market forward rates broadly do not show noticeable counterparty risk premia. Finally, Du, Tepper and Verdelhan (2018) show that CIP has not held intermittently since the financial crisis. While this makes it harder to claim that the forward premium adequately represents cross-country interest rate differentials, it actually makes this way of calculating international interest rate differentials more representative from the perspective of a global investor who may face the same frictions that prevent CIP from holding in recent years.

In addition, I compute log quarterly returns on a long-short equity portfolio in each country, by going long stocks in the non-traded sector and short stocks in the traded sector:

$$r^j_{NT,t+1} = dr^j_{N,t+1} - dr^j_{T,t+1}, \tag{3}$$

where $dr^j_{m,t+1}$ describes the value-weighted USD return of the portfolio in sector $m = N, T$ between t and $t+1$. I compute these portfolios using MSCI sector indices available at the country-level. Following the literature, I consider 'Health Care' and 'Financials' sector indices as the inputs for the non-tradable sector portfolio, and 'Industrials' and 'Materials' for the traded sector. Clearly, this separation is imperfect and does not capture the full universe of stocks in each individual country.[12] However, by making the distinction between the long and the short side of the portfolio less systematic, this should make returns more random, and therefore make it harder to find a statistically significant relationship with my explanatory variable. I calculate value-weighted returns by scaling each sector's returns by the its relative weight in the portfolio. Also from MSCI, I calculate the 'investable share ratio,' which captures the relative market capitalization size of the country's

[12] 'Consumer staples' and 'Consumer Discretionary' are other large sector indices but cannot be clearly distinguished as tradable or non-tradable sectors for all countries under study, for example.

MSCI index to the total domestic stock market index, explained in more detail below.

3.2 Foreign Ownership and Asset Returns

3.2.1 International Bond Returns

To test if there exists a relationship between home bias and asset returns, I first regress quarterly excess currency returns, defined as the return on the currency forward versus the USD relative to the spot exchange rate, on lagged portfolio liabilities from the CPIS, scaled by GDP, a set of controls X_t, and time-fixed effects α_t:

$$r_{t+1}^{j} = \kappa + \alpha_{t+1} + \beta^{s} Q_{t}^{j} + X_{t}^{j} \gamma^{s} + \epsilon_{t+1}^{j}. \tag{4}$$

As in all the regressions in this paper, standard errors are heteroskedasticity-robust and clustered at the country level. The coefficient estimate comes out to around negative 3 bp of log excess returns per percentage point of portfolio liabilities to GDP, annualized. For reference, this translates into a return differential of -0.9 percent between holding Canadian dollars, where average foreign ownership of domestic assets is about 60 percent of GDP over the sample, and New Zealand dollars, where it is about 30 percent - a quite sizable number just explained by variation in foreign investor presence.

A number of recent papers have studied international return differentials, in particular in currency space, and have proposed a broad set of possible explanations. As visible in Table 2, neither of these changes size or statistical significance of the coefficient on my choice variable in a substantive way: Hassan (2013) shows that relative country size is significantly related to return differentials, which I control for in column 2. Exchange rate volatility, in column 3, also plays an important role in determining returns - however this does not change the significance of foreigners' domestic asset holdings. Finally, related in spirit although quite different in practice from my work here is Della Corte et al. (2016), who highlight the role that **net** international investment positions (NIIP) play in determining returns. Citing Gabaix and Maggiori (2015), they show that net borrower countries generally pay higher returns than net lenders, in particular if they issue debt in foreign currency. However, as the regression here shows, this does not explain away the relationship between *gross* portfolio liabilities and asset returns.

In regressions not shown here, I confirm that additional factors do not change my results: I control for the share of debt issued in USD from Benetrix, Lane and Shambaugh (2015), which is also highlighted as a driver of returns in Wiridinatu (2018), and confirm my initial results.[13] Ready, Roussanov and Ward (2015) emphasize the special role of commodity exporters in global production networks in explaining systematic variation in international returns: Again, I confirm the significance of their results but find that my measure of foreign participation is still significant and large after controlling for their measure of the import ratio.[14]

The empirical results give robust evidence for a strong inverse relationship between international currency returns and foreign investor presence in domestic asset markets. Foreign ownership variation appears to be a consistent predictor of the failure of uncovered interest rate parity. A natural next step is to test wether this violation comes from spot exchange rate moves relative to the USD, or is due to interest rate differentials.

3.2.2 Interest rate differentials

I now regress the forward premium on foreign ownership, which as discussed above is a credible measure of international interest rate differentials. Table 3 shows a negative relationship, where countries with low foreign ownership have higher interest rate differentials relative to the US. This result is robust to controlling for the alternative drivers of international return differentials discussed above: Nominal exchange rate volatility matters for interest rate differentials, and the net import ratio is positively related to forward premia as well. Lastly, net borrower countries pay higher interest rates than net lenders - but again all these factors do not impact the significance of the foreign ownership coefficient.

Importantly, the documented relationship is not due to inflation differentials. Using ex post real interest rate differentials, for consistency now calculated as the 1-year forward premium less the 1-year forward realized year-on-year CPI inflation rate, preserves the results (see table A2 in the appendix).[15]

The regression results in Table 3 also show that in terms of magnitude, the currency return differentials match closely to interest rate differentials, highlighting the clear failure of UIP along this dimension: An increase in the foreign ownership share of one percentage point of GDP leads to a decrease in the forward premium of more than 5 basis points on an annualized basis. Again, using

[13] Controlling for foreign currency issuance share rather than USD share does not change the results.

[14] I thank the authors for sharing their data with me.

[15] Since standard errors are clustered at the country level, overlapping time periods do not pose an issue here for interpretation.

the comparison between Canada and New Zealand, the interest rate differential due to differences in foreign investor presence adds up to more than -1.5 percent difference per year on average.

3.2.3 International Index Stock Spreads

I can further extend the analysis to stock markets. I consider the quarterly return on a country's MSCI index. The index consists of stocks are directly available to foreign investors, and oftentimes the index can even be accessed through specific index funds (such as exchange-traded funds that replicate the performance of said index). Here again, returns are denominated in USD, although the results also persist with local currency equity returns, and include dividends. The results are presented in table 4.

As before, stock returns and foreign ownership are strongly negatively related. Per percentage point of GDP, foreign ownership decreases stock returns by 4 basis points. In the example of Canada and New Zealand, this would make for a consistent return differential of 1.2%. Importantly, while the regression results survive controlling for variables like country size and exchange rate volatility, the regression struggles to disentangle the effects of foreign ownership and the net international investment position. When the foreign ownership variable is refined to be more equity-specific (i.e. the foreign ownership share of the domestic stock market), the coefficient on foreign ownership is again highly significant even when net portfolio positions are included (see figure A3 in the appendix).

3.2.4 International Sector Stock Spreads

Lastly, I test if foreign ownership predicts the spread between non-traded and traded sector stock returns. As described above, I generate value-weighted traded and non-traded sector indices to test this prediction in the same regression setting as bond returns, while controlling for the same set of explanatory variables for international return differentials. Since they are expressed as the USD return on the long-short portfolio, we can interpret the regression results without concerns about differential sector sensitivity to inflation or cross-country variation in average equity returns over the sample period, which might be due to unobserved drivers.

The regressions in Table 5 again uncover a strong inverse relationship between the return spread and the foreign ownership share: The relative return on non-traded sector stocks relative to stocks in the traded sector decreases by 7 basis points per percentage point of foreign ownership share, annualy. To stick with the previous example, this translates into a more than 2 % percent outperformance of the non-traded/traded portfolio in favor of New Zealand relative to Canada on an annual basis.

In conclusion, the data on international asset return differentials and the extent of foreign participation in local asset markets show a noticeable, inverse alingment. Furthermore, the results indicate that the relationship is not just statistically but also economically large: Orthogonal to other drivers of return differentials or risk exposures, differences in foreign investor participation predicts asset return differentials between 1.2 and 1.8 percent per year, per standard deviation of foreign ownership, for bonds and relative stock returns respectively. As discussed above, these results show a connection between the portfolio home bias and the international return differential puzzle. They also pose a serious issue to standard explanations of return differentials since at face value, the connection between portfolio holdings and returns suggest that foreign investors systematically underallocate to higher-return countries. In a model where returns reflect underlying exposure to global risk, this further means that local investors in high-risk exposure countries appear to be less internationally diversified than those in low-risk exposure countries.

In order to explore the underlying driver of this relationship, I next expand the analysis to consider a more fundamental driver of the variation in foreign ownership, borrowing from the portfolio home bias literature.

3.3 Agency Frictions, Foreign Ownership and Asset Returns

Might there be a common root for the portfolio home bias and asset return differentials? One interesting finding in the literature is Dahlquist et al. (2003), who document that for the portfolio allocation of US equity investors, a country's float-adjusted world portfolio share is a better predictor of actual allocations than is the standard market capitalization-based measure. Float differs from market capitalization by taking into account that some firms have large amounts of insider ownership, or investors with control rights, so that only parts of a firm's market capitalization are actually freely available for purchase by outside investors. Following this logic, countries where insider ownership is larger will have smaller amounts of floating shares available to international investors, and hence will have a lower weight in international investors' portfolios, leading to stronger home bias in the data.

In this section, I follow this argument to test if insider ownership can explain cross-country variation in foreign ownership shares, and subsequently, asset return differentials. I find that they do. My measure of a country's stock market's investable share, which can be taken as a measure of the severity of corporate level agency problems in an economy, succeeds in explaining cross-country variation of foreign ownership, not just for equity but for total portfolio holdings. Secondly, using the investable share as an instrument for foreign ownership preserves and even sharpens the asset pricing results from above.

3.3.1 The Investable Share as a Measure of Corporate Agency Frictions

I first outline the new measure of a country's investable share. In order to invest in particular countries, many professional investors rely on benchmark indices constructed by MSCI. MSCI is a stand-alone public company that provides research and market analytics. In the process of mapping a country's stock index, the provider considers the full equity market universe and then makes certain adjustments in order to ensure that the index is actually implementable for investors, in particular global ones. In considering each publicly traded stock individually, MSCI looks at issues like firm size and market liquidity [16]. But most importantly, especially for larger firms, MSCI also looks at the corporate ownership structure. When firms have large amounts of strategic or insider ownership, then the firm's market capitalization in the index is scaled by the freely available float in public markets, so as to make sure that an international investor can feasibly achieve a portfolio that mimics the index in practice.[17] I exploit this insight to calculate a widely available and dynamic proxy for the severity of corporate agency frictions, as measured by corporate insider ownership, which I denote the investable share:

$$Investable\ Share = \frac{MSCI\ Index\ Total\ Market\ Capitalization}{Total\ Country\ Stock\ Market\ Capitalization}.$$

To highlight the scope of this score, a case study is instructive: Banco Bradesco is one of the major private-sector financial institutions in Brazil, with an official market capitalization of \$ 60 bn.[18] The firm has a corporate structure in which shares outstanding are split evenly between common shares with voting rights, and preferred, non-voting shares. Both share classes are individually part of the MSCI Brazil index, however, while about \$30 bn worth of preferred shares are included,

[16] I.e. at least 15% of a stock's market capitalization needs to have been traded at an annualized rate in EMs (20% in DMs), and the stock must have at least traded for 3 months.

[17] Hau et al. (2010) study the discrete implementation of this MSCI policy that took place in 2001 and 2002, which led to large shifts in relative country allocations in large global indices.

[18] All figures as of November 2019.

less than \$10 bn worth of common shares are part of the MSCI. As a result, Banco Bradesco is only included with a float-adjusted market capitalization of two thirds of its actual USD amount. Looking at the corporate ownership structure, the reason quickly becomes apparent: An investment vehicle co-owned by the firm's management as well as the founding family owns two thirds of all common shares, but none of the preferred ones. As a result, the ratio of the MSCI float-adjusted to actual total market capitalization represents effectively the extent to which the company's shares are not owned by corporate insiders, highlighting the usefulness of this simple measure. In additional empirical tests (not shown here), I relate the investable share to other measures of legal efficiency and ownership concentration across countries. This reinforces the notion that it serves the purpose to capture cross-country variation in insider ownership well, which in turn can be thought of as representative of corporate agency frictions.

3.3.2 Agency Frictions, Foreign Ownership and Asset Returns

Next, I first establish an empirical link between agency frictions as measured by the investable share and the extent of foreign ownership in an economy. I regress the observed foreign ownership share on the contemporaneous investable share and time-fixed effects, while, as before, clustering standard errors at the country level. As visible in Figure 2, the investable share does very well in explaining cross-sectional variation in foreign ownership, and the scale of the estimated linear relationship (Table 6) is intuitive: Going from a 0 investable share, i.e. a (hypothetical) market in which none of the aggregate stock market capitalization is considered investable by MSCI, to a score of 1 (the whole market is fully investable for outside investors) alignes with a foreign ownership difference of 100 percent of GDP, about equal to the range of foreign ownership shares observed in the sample. Importantly, while the regression results are robust to time-fixed effects, the investable share does less well in predicting time-series changes in foreign ownership. This is not necessarily a negative result: Gross portfolio liabilities show some cyclical variation that is most likely not due to underlying, longer-run frictions in capital markets.

Using the just established relationship as the first stage, I now regress future asset returns on foreign ownership, using the investable share as an instrument. The results in table 7 confirm and sharpen the original results. Coefficients are highly significant and noticeably larger than in the non-instrumented regression. One additional percentage point difference in foreign ownership share, as predicted by a country's investable share, changes a country's expected currency returns by -7 bps per year, relative to -3 bps in the original regression. Interest rates, as measured by the annualized 3-month forward premium, are -8 bps lower (relative to -5 before), while equity returns move by -18 bps for the market index (against -4 bps before), and -11 bps on the relative return of non-traded relative to traded sector stocks (vs -8). Table A4 in the appendix shows that these results are robust to including other explanatory variables for return differentials discussed above.

The results suggest two main insights: First, the asset pricing properties of the foreign ownership variable appear to originate in the cross-country variation in the investable share, i.e. the severity of the corporate agency friction. Second, while the instrumental variable approach increases coefficient size in all assets, the increase is especially pronounced in equity markets. This is intuitive since the measure for the underlying friction is uniquely sourced from equity markets. While it is unlikely that frictions in debt and in equity markets are completely independent of each other, further research could explore if measures of debt market frictions could help in sharpening the results for currency returns and interest rates.

Most importantly, the analysis shows that corporate-level agency frictions seem to matter for asset returns, even thought all assets under study - FX, interest rates, and equities - are freely available to foreign investors. Equity returns are computed using the MSCI indices, which already take into account that some stocks might not actually be available for purchase, and are themselves broadly available through exchange-traded funds (ETFs). Currencies are directly accessible through forward contracts that are traded on international exchanges and with international broker-dealers. This makes tracing out the channels through which agency frictions affect asset prices substantially harder. Since there are no immediate barriers to foreigners' participation in these markets, we cannot simply explain asset return differentials as the result of market entrance costs, for example.

Instead, as I show below, a more promising avenue is to explore a more indirect mechanism. Agency frictions first show up in restricting outside investor ownership, which matters in particular for foreign investors. In turn, this forces larger amounts of domestic risk exposure to be held locally, rather than by (potentially diversified) outside (foreign) investors. As a result, local agents may demand a higher risk premium in countries where less diversification is possible. In section 4, I construct a simple international asset pricing model that, building on this logic, can reconcile the two new sets of empirical results outlined here. However, before diving into theory, one might wonder how substantial these asset return regularities are, or, put differently, how much they matter in capital markets as measured by actual investment performance. I explore this question next.

3.4 Factor structures in returns

How persistent are return differences between countries along the axis of agency frictions, or foreign ownership rates? Building on an extensive literature in finance (Fama and Macbeth, 1973), sorting individual assets into portfolios based on the proposed explanatory variable promises to reduce idiosyncratic error and to crystalize the effect of cross-sectional variation in the variable. Lustig and Verdelhan (2010) first brought this approach to the systematic study of exchange rates, and it has since been used in other work close in spirit to this paper, such as Ready, Roussanov and Ward (2015), Richmond (2018), and others. With this approach, I provide additional evidence for the persistent and economically significant relationship between agency frictions, foreign ownership and asset returns, in a manner that can also directly be implemented as a trading strategy.

In accordance with the literature, I first rank all countries in my sample based on their investable share for every month.[19] Then, I use this ranking (again in each period) to sort each country into five distinct, even-weighted portfolios and calculate aggregate returns for currencies, equity index and relative equity portfolios. For comparison, I also compute similar portfolios using each country's forward premium, which replicates the standard carry trade. Table 8 provides the characteristics of the resulting portfolios. Importantly, while countries are sorted on each variable only once, the ranking can be implemented in three different assets - currencies, equity indices, and relative equity sector portfolios (non-traded vs traded sector). At the bottom of the table, I provide the characteristics of each portfolio for the three sorting variables.

Starting with the sorting variables, the three ranking techniques all show some degree of alignment (Table 8). For portfolios ranked by investable share, the average score of each country portfolio varies from 0.17 for the "Low" portfolio to 0.67 for the "High" portfolio. For the portfolios resulting from the sorting based on forward premium, the variation is smaller (as expected, since they are built using a different sorting variable) but still weakly monotonically increasing. In reverse, the investable share portfolios also show strong alignment with forward spreads, but much less so than the portfolios directly constructed on them. As a result, all portfolio sorting mechanisms show similarities: Low investable share countries also tend to have low foreign ownership, and high forward spreads, confirming result 2 from above.

Since the portfolio sorts look related, the asset pricing results also show some parallels. On both sorts and for all assets, portfolio 1 produces high and portfolio 5 (usually) low returns. We can

[19] I always sort on the last known value at the beginning of the month to preserve realism.

exploit this relationship in order to generate a "zero-cost" portfolio strategy that goes long portfolio 1 and short portfolio 5. As is common in the literature, we can refer to these as factors. I call the factor resulting from sorting on the investable share *INV*, and use *HML* to refer to the forward premium factor (as in Lustig et al. 2011).

I now consider each asset class separately. For currency returns, the results look highly attractive across the board. While raw returns over the last 18 years have been highest for the HML factor, so has volatility. As a result, not only does the *INV* factor have a noticeably better Sharpe ratio than *HML* (1.2 vs. 1),[20] the former also has displayed positive skew (0.4 relative to -0.5 for *HML*). In addition, *INV* has experienced a much lower maximum drawdown over the sample period, which after all includes the Great Financial Crisis. Lastly, although the ex-ante forward premium in the *HML* strategy is more than double that of its competitor, much of it is given back to nominal exchange rate depreciation. In contrast,*INV* actually benefits from nominal exchange rate moves, with currencies in the long end of the portfolio showing spot rate appreciation in excess of those in the short end.

The rows below show how the same sorting process works in equities. Here, there are even clearer differences between strategies: The forward premium sorting is not at all applicable to equity markets, as the *HML* implementation produces a low Sharpe ratio of 0.2 However, the *INV* factor is particularly strong in equity indices, and produces a Sharpe ratio of 1.8. Interestingly, the volatility of the two factors is quite similar, while the achieved mean returns are vastly different. Apart from the immediate investment implications, this strong separation provides a fundamental insight: On the one hand, nominal interest rate differentials do not provide a helpful sorting mechanism for equity investments, duly in part to the fact that - from the perspective of a USD investor - spot exchange rates move against the position. On the other hand, investors are compensated along the axis of market accessibility frictions in both equities and currencies (which earn the local interest rate less spot rate depreciation).

Lastly, consistent with result 4 above, the portfolio sorting is also implementable in relative equity sector portfolios. To this end, building on the same sorting mechanisms for all countries in the sample, I group together the performance of non-traded sector relative to trade sector stocks in

[20] These are high numbers for a relatively simple strategy, also in comparison to other studies of the carry trade in currencies. The difference can be traced back to both differences the country sample, and time period under study. Given the more recent availability of the CPIS data, my data starts later and includes a particularly good time for the carry trade, especially in emerging markets. In general, my sample skews more towards developing economies, which commensurately has meant higher forward spreads. At the same time, given that my sample starts in 2001, I do not include the large set of individual currencies that were subsumed by the Euro in 1999.

each country. The resulting factors show reasonably good Sharpe ratios of 0.45 (for INV) and 0.47 (for *HML*), but these obviously pale in comparison to the currency and equity implementations.

A notable observation about international asset returns, especially in currency space, is the extremely strong performance of Emerging Markets (EM) economies win the mid-2000s. The first panel in Figure 3 shows that the currency carry trade (*HML*) performed very well for the first half of the sample but has been moving broadly sideways since the financial crisis. In comparison, the INV factor has performed substantially better over the long run, and shows no signs of a similar drop in performance. Similarly, the the performance of the INV implementation in equities (middle panel) shows no signs of a drop in performance.

Lastly, how new is this way of slicing the universe of international assets? I follow Asness et al. (2013) and compute an aggregate factor of the volatility-matched FX and equity strategy, and find that the new factor shows a near zero-correlation with global value and momentum factors (0.05 and 0.04, respectively). The intermediary factor from Kelly, Manela and He (2017) does no better, nor do other standard US-focused asset-pricing factors.

The results from the factor structure analysis allow for two insights: First, cross-country variation in the investable share appear to be strongly related to asset returns, and provide substantial financial returns. Second, strategies based on (one of) the fundamental drivers of interest rate differentials, while reasonably closely related, do at least as good if not better than those that are based on observable interest rate differentials. Perhaps most interestingly, while interest rate differentials are useless in trading equities, variation in the investable share contains substantial information about future returns in both currencies and equities. In combination, the results suggest that using market frictions as a sorting mechanism can generate a more stable, more profitable, and more widely implementable carry trade than the traditional approach.

3.5 Evidence on Limits to Consumption Risk Sharing

How can we make sense of this close connection between gross international portfolio positions, market accessibility frictions, and asset returns? Standard international asset pricing models that rely on complete markets are not able to nest these links, since all agents in the model have perfect insurance against idiosyncratic risk. As a result, portfolio positions (and hence, market frictions) are irrelevant, and returns only align with the asset's exposure to global aggregate risk. In this section, I show that the perfect risk sharing assumption is not backed up in the data, and that variation in the investable share aligns with the exposure of the domestic consumption process to domestic output dynamics.

Figure 4 shows this insight in the most immediate form. The x-axis shows a country's investable share, i.e. the extent to which domestic assets are considered to be freely available to foreign investors. The y-axis on the other hand shows the β coefficients from a simple regression of a country's real consumption growth on its real GDP growth (both in PPP terms). When the consumption β is high, then a shock to domestic output feeds more directly into domestic consumption. When β is low, then disturbances to domestic output feed through less directly to domestic consumption, potentially because more international insurance (risk sharing).

In the graph, the line of best fit implies that countries with a lower investable share have higher exposure to domestic output shocks, seemingly suggesting that risk sharing is lower in those countries. However, it may well be the case that countries with lower investable shares also have an output process that is more closely aligned with global output. Under those circumstances, the lack of risk sharing would not be due to market frictions but instead would simply be driven by the uninsurable nature of global output shocks. To address this concern, we can test the relationship in a panel regression. Here, I regress local real consumption growth on real GDP growth, the investable share, and their interaction terms. To isolate the effects of the capital market friction, I include country fixed effects (to account for mean differences in consumption growth), and time-fixed effects, which proxy for the global cycle.

If consumption risk sharing was complete, then the time-fixed effects should wash out all (systematic) variation in consumption growth, since global growth shocks should be shared perfectly across countries. However, as the results in table 9 show, this is not backed up by the data: Domestic real GDP growth is highly significant in predicting contemporaneous real consumption growth. However, the coefficient on the interaction term is negative, which means that the influence of output growth is decreasing in a country's investable share. As a result, even when accounting for global output shocks and other factors, local consumption is more exposed to local dynamics when financial integration is more limited. I build on this key insight in the theoretical section by building a theoretical model that connects limits to foreign ownership of domestic assets to the exposure of the domestic agent's pricing kernel to local shocks.

4 Model

In this section, I present a simple version of the traditional international asset pricing model from Backus and Smith (1993), augmented with a financial friction. As a result, the model allows for the study of asset prices in economies with limited risk sharing, which generates rich variation in exchange rates and asset returns in response to variation in international portfolio allocation. In more detail, the model shows that countries with more international risk sharing - through larger foreign ownership of domestic assets - have lower interest rates, lower currency risk premia, and higher stock returns in aggregate and in the non-traded relative to the traded sector.

The inclusion of a financial friction and the emerging importance of country portfolios makes a standard social planner solution infeasible. By relying on some simplifications and explicit functional forms, I preserve tractability and find an analytical solution.

4.1 Set-up

The economy consists of N identical small open economies indexed $i = 1, ..., I$. Each country has a representative local household and two Lucas trees, one producing the tradable and one the non-tradable good. There are two time periods, $t = 1, 2$. At $t = 2$, each country realizes a shock to the growth rate of each tree's production (shocks are normalized to 1 in period 1). Shocks are assumed to be log-normal and i.i.d. across countries so that

$$\Delta d^i_{j,2} \sim N(\overline{\Delta d_j}, \sigma^2_j) \quad j \ = \ T, N. \tag{5}$$

For simplicity, I assume that shocks are i.i.d. within each country as well, so that $\sigma_{N,T} = 0$. In the following, lower case letters always refer to the log of the denoted variable.

The representative household in each country consists of two parts, an "agent" that makes consumption and savings decisions, and an "operator" that harvests the trees and delivers the proceeds to the household. The local agent in each country faces a global investor. I assume that in period 1, shipping goods is not possible. As a result, when the global investor buys a share in the domestic tree, the local agent gets a commensurate amount of global risk-free bonds that pay out in traded goods.[21] Because of the initial no-trade assumption, the local agent cannot freely pick

[21]For simplicity, I implicitly assume that the lobal investor exchanges bonds for trees 1 : 1, and not at the endogenous, locally determined asset price but I relax this assumption in an extension in the appendix.

her foreign asset holdings and is constrained by the quantity of local assets that the global investor demands. The quantity of global investor local asset ownership matters for the local operator: The operator harvests the trees in each period and decides wether to pay out the global investor's share of returns, or to keep all for the local household.

4.2 Local Agent

The local representative agent solves an inter- and intratemporal utility maximization problem in markets for goods and assets. She maximizes the expected utility function

$$U^i = \sum_{t=1,2} e^{-\delta} \frac{(C_t^i)^{1-\gamma}}{1-\gamma}, \tag{6}$$

where $e^{-\delta}$ is the common discount factor and γ denotes the measure of risk aversion. The local agent derives utility from the consumption bundle C_t, which is a composite of the tradable and the non-tradable good with relative utility weight $\tau \in (0, \frac{1}{2})$ on the traded good, so that

$$C_t^i = (C_{T,t}^i)^\tau (C_{N,t}^i)^{1-\tau}. \tag{7}$$

The local agent maximizes expected utility given the following budget constraints:

$$C_1^i = (D_{T,1}^i)^\tau (D_{N,1}^i)^{1-\tau} = 1,$$

$$C_2^i = ((1-Q^i)D_{T,2}^i + Q^i R^*)^\tau (D_{N,2}^i)^{1-\tau}, \tag{8}$$

where Q^i marks the extent to which foreign investors are holding shares in the local trees, and the amount of global risk-free bonds, delivering R^* units of the traded good with certainty, that the local agent gets in return. $D_{j,t}$ denotes the dividends from the trees producing traded (T) and non-traded (N) goods respectively.

In each period, the agent solves an intratemporal expenditure minimization problem, which determines the relative price of the non-traded in terms of the traded good, which is considered the numeraire for all expressions in this paper:

$$P_N^i = \left(\frac{1-\tau}{\tau}\right)\left(\frac{C_T^i}{C_N^i}\right), \tag{9}$$

where C_N^i and C_T^i denote the actual amounts consumed of the traded and the non-traded good, respectively in country i. Using the consumption bundle, the domestic price level, defined as the cost of one unit of domestic consumption in terms of the traded good, is then

$$P^i = \frac{1}{\tau}\left(\frac{C_T^i}{C_N^i}\right)^{1-\tau}. \tag{10}$$

Furthermore, the agent solves an intertemporal portfolio allocation problem. Since there is no storage technology in the economy, asset prices need to adjust so that the agent's Euler equations hold and markets clear for all assets in the economy, given the global investor's ownership share Q:

$$1 = \mathbb{E}\left(e^{-\delta}\left(\left[\frac{(1-Q^i)D_{T,2}^i + Q^i R^*}{D_{T,1}^i}\right]^{\tau}\left[\frac{D_{N,2}^i}{D_{N,1}^i}\right]^{1-\tau}\right)^{-\gamma}\frac{P_1^i}{P_2^i}\, R_{j,2}^i\right). \tag{11}$$

In an important contrast to the canonical Backus-Smith model, asset prices are determined by both traded and non-traded endowment **of the local agent** (and not by the global aggregates). This difference comes from the assumption that agents do not have access to complete and frictionless global financial markets. Instead, since risk-sharing is limited, each local economy has its own pricing kernel. The reason for incomplete global risk sharing and the existence of a local pricing kernel is driven by the second role of the domestic household: operating (or harvesting) the local trees.

4.3 Local Operator

Even though the global investor can purchase shares in the local trees, she cannot directly observe the realized dividends. Instead, she relies on the local operator to report and pay out the true returns. If she suspects that she has been cheated, the only means of recourse for the global investor is to pursue a claim in court. In this case, she can sue and impose a penalty as a share ϕ^i of the realized return, which varies with the strength of the local legal system. The local operator hence faces the following problem in deciding whether to report truthfully and pay foreign investors their share of returns Q^i, or to claim a total loss, keep all returns for the domestic household, and incur the penalty rate ϕ^i:

$$\max_{\mathbb{I}=0,1} \quad (1-Q^i)D_{j,2}^i \cdot \mathbb{I} + (1-\phi^i)D_{j,2}^i \cdot (1-\mathbb{I}). \tag{12}$$

It is straight-forward from the linearity of the problem that for any foreign share Q^i above the penalty rate ϕ^i, it will be optimal for the local operator to always claim a complete loss on the local tree and pocket the full harvest for herself. However, when the foreign share is smaller than the legal costs threatened in the case of untruthful reporting, it will be in the local agent's interest to treat the foreign investor's claims fairly.

4.4 Global Investor

The global investor is assumed to be risk-neutral and deep-pocketed. She only maximizes consumption of traded goods in period 2 by investing in the local risky asset and funding out of the global risk-free bond at the exogenously determined interest rate R^*:

$$\max_{Q} \quad V = \mathbb{E}\left(\Delta d^i_{T,2} - r^*\right) Q^i. \tag{13}$$

As a result of this extremely simplified portfolio problem, the global investor would like to take the maximum allowable long position in the domestic tree if the expected return is higher than the global risk-free rate. What prevents the global investor from doing this is the local operator's incentive compatibility constraint: If the global investor owns a share Q^i larger than the claw-back share that can be imposed on the local agent in the case of false reporting, then the reported return on the local tree will always be 0.

Given the simplicity of the mechnaism, one could imagine a more realistic portfolio allocation problem, with risk aversion and global asset covariances or leverage constraints. However, as long as the global investor puts a higher value on holding the local asset than the local agent (for example because at least some fraction of the local risk can be diversified away in a global portfolio), the results for foreign participation discussed above still hold.

5 Results

In comparison to the standard Backus-Smith model, the loss of perfect asset markets makes solving the model through a planner's problem infeasible. Instead, the mode requires solving for asset prices and portfolio holding quantities for the global and the local investor for each country separately. As I show below, asset prices are determined by the local agent's Euler equation, while portfolio quantities are determined by the oversight friction.

5.1 Foreign Ownership Share

Condition 1: *The global risk-free rate is lower than the mean dividend growth rate of the traded-fruit tree and higher than the autarky traded good bond rate:*[22]

$$\overline{\Delta d_T} > r^* > r^{aut}.$$

Under condition 1, the global risk-free bond has a lower return than the mean growth rate of the traded good endowment, while offering a higher return than a bond paying of in traded goods, traded in the domestic economy in autarky. This insures that for both the local agent and the global investor, this trade is desirable.

Proposition 1: *If domestic legal protection is weak (false reporting penalties are low), then foreign participation Q in the domestic asset market will be low. In equilibrium, the foreign ownership share is pinned down exactly by the legal penalty that can be imposed:*

$$Q^i = \phi^i \tag{14}$$

Proof: *See Appendix.*

5.2 Prices and Exchange rates

As shown in (6), the local price index, denominated in the traded good, is a function of the relative consumption of traded and non-traded goods by the local agent. The log change in the price index from period 1 to period 2 is hence

$$\Delta p_2 = (1-\tau)\left(\Delta c_{T,2} - \Delta c_{N,2}\right). \tag{15}$$

The real exchange rate for the domestic economy h, relative to a foreign country f, is defined as the

[22]The autarky interest rate on a bond that pays out in traded goods is the same in all countries and defined as: $r^{aut} = \delta + \gamma\tau\overline{\Delta d_T} + \gamma(1-\tau)\overline{\Delta d_N} - \gamma\tau(\frac{\gamma\tau}{2} + (1-\tau))\sigma_T^2 + \gamma(1-\tau)^2(1-\frac{\gamma}{2})\sigma_N^2$.

ratio of their respective price indices,

$$s^{f,h} = p^f - p^h, \tag{16}$$

where a higher ratio marks a weaker home currency. The change in the real exchange rate is therefore defined as the ratio of the changes in the two price indices:

$$\Delta s^{f,h} = (1-\tau)\left[(\Delta c_T^f - \Delta c_T^h) - (\Delta c_N^f - \Delta c_N^h)\right], \tag{17}$$

Under the assumption that all countries are identical, with the exception of the strength of legal protection for foreign investors (and hence the extent of foreign ownership of domestic assets), I can solve for the expected change in the real exchange rate between home and foreign:

$$\begin{aligned}\Delta\mathbb{E}(s_2^{f,h}) &= log\ \mathbb{E}\left(\frac{P^f}{P^h}\right) - s_1^{f,h} \\ &= (1-\tau)\left[\left(\frac{\overline{\Delta d_T} - r^*}{\sigma_T^2}\right) + (1-\tau)\left(1 - \left(\frac{Q^h + Q^f}{2}\right)\right)\right]\sigma_T^2(Q^h - Q^f),\end{aligned} \tag{18}$$

where the second term in the square brackets comes from the log-normality of the underlying shocks. Under the assumption that domestic households cannot go short in the domestic assets, foreign ownership in each country is naturally capped at 1 and this expression is always positive. Non-traded endowments drop out in expectation since countries are assumed to be identical apart from Q^i. Under condition 1, when the global investor owns fewer assets in the home economy so that $Q^h < Q^f$, the home currency is expected to appreciate as the ratio between the two price indices falls. The relative appreciation of the home currency comes from the increasing relative scarcity of the non-traded good in the home country. Since higher foreign ownership means that the domestic agent holds more risk-free global bonds that deliver a safe but lower return, and fewer shares in the risky but faster-growing tree, countries with more foreign ownership will see slower growth in its tradable consumption on average. This, in turn, means that the domestic non-traded good will be relatively less valuable. While this relationship predicts spot exchange rates, this does not tell us anything about actual return differentials. For this, we have to consider the actual return on local currency bonds.

5.3 International Bonds and Interest Rate Differentials

Definition 1: *A domestic risk-free bond is an asset that delivers exactly one unit of the domestic consumption bundle in every state of the world. Denominated in terms of the tradable good, the payout is equal to the domestic price index P.*

Keeping with the literature, the domestic bond is defined to be risk-free for the domestic household as it delivers exactly one unit of the domestic consumption bundle. For the global investor who cares about returns in terms of the tradable good, this means that returns on the bond will be high when domestic non-traded goods are scarce, and low when they are plentiful - all relative to the domestic household's total endowment of traded goods in the next period.

Condition 2: *The parameters of the model are confined to be such that*

$$3\left(\frac{1-\tau}{\tau}\right) > \gamma > \frac{1-\tau}{\tau} \tag{19}$$

and

$$\frac{\overline{\Delta d_T} - r^*}{\sigma_T^2} > \frac{(\gamma\tau)^2 + (1-\tau)^2}{\gamma\tau - (1-\tau)} \tag{20}$$

The above condition relates the risk-return characteristics of holding local risky assets relative to global bonds, scaled by the variance of traded goods output growth, to the relative risk aversion and preference for non-traded relative to traded goods consumption of the domestic household. When foreigners purchase local assets, the domestic household gains exposure to a lower-risk but also lower-return asset. If this condition is satisfied, then the diversification benefit from increased foreign ownership will not be overmatched by countervailing precautionary savings motives.[23] In the appendix, I show that the implied restrictions on the parameters are reasonable in a numerical setting relative to the observed data on asset returns and volatility.

Domestic bonds are assumed to be in zero-net-supply and foreign investors cannot directly participate. Since all countries are assumed to be identical apart from the strength of the agency friction, expected returns do not depend on any country-specific factors apart from the foreign ownership share. Hence, the domestic representative agent's Euler equation determines the market-

[23] Since traded good income is now less risky, domestic households might be less inclined to accumulate precautionary savings, which would push up the local risk-free rate, at least if risk aversion is very high.

clearing expected return, here again denominated in the traded good:

$$\begin{aligned} log\ \mathbb{E}(R_P^i) = \delta + \gamma\tau\left[(1-Q^i)\overline{\Delta d_T} + Q^i r^*\right] + \gamma(1-\tau)\overline{\Delta d_n} \\ - \frac{(\gamma\tau)^2}{2}(1-Q^i)^2\sigma_T^2 - \frac{(\gamma(1-\tau))^2}{2}\sigma_N^2. \end{aligned} \tag{21}$$

The expected return on the domestic bond is increasing in the expected growth rate of traded and non-traded good production, and decreasing in the variance of both. The signs on the expected dividend growth rates are as expected - higher consumption tomorrow requires a higher interest rate to motivate agents to save today. At the same time, when the variance of traded and non-traded dividend growth is higher, the local household has a stronger precautionary savings motive, which puts downward pressure on risk-free rates.

Importantly, given condition 2, expected returns on the risk-free bond are always decreasing in foreign ownership Q^i. There are two effects: First, the exchange of shares of the domestic tree for global risk-free but lower-yielding bonds means that the traded good endowment of the domestic household will grow more slowly, on average. This lowers the required expected return today through decreasing total wealth. Second, while global bonds are lower-yielding, they are safe in terms of the traded good. As a result, the domestic agent's traded good endowment is fluctuating less as foreign ownership increases, which reduces the need for precautionary savings in a non-linear fashion. Again, one can compare across countries h and f, identical apart from the strength of legal protection, to show systematic variation in the traded good-denominated bond returns based on foreign ownership.

Proposition 2: *The difference in expected returns of two countries' risk-free bonds is given by*

$$log\ \mathbb{E}(R_P^h) - log\ \mathbb{E}(R_P^f) = \gamma\tau\left[\frac{\overline{\Delta d_T} - r^*}{\sigma_T^2} - \gamma\tau\left(1 - \frac{Q^f + Q^h}{2}\right)\right]\sigma_T^2(Q^f - Q^h), \tag{22}$$

,

where Q^h and Q^f denote the foreign ownership share in each country h and f, respectively. Under condition 2, bond returns are systematically higher in the country with lower foreign ownership share.

Proof: Take the difference of (22) between two countries that are assumed to be identical apart from the foreign ownership share Q^i. All terms not related to the relative values of Q^i drop out, leaving expression (17) after rearranging. Under condition 2, the term in the bracket will always be positive.

The bond return differential consists of two parts. First, higher bond returns in the lower foreign ownership country come from increased mean consumption growth of the tradable good in the second period in expectation, relative to the global risk-free rate and the dividend variance. The second part captures the countervailing precautionary savings motives, which are higher in countries with a lower foreign ownership share. In combination, under condition 2, the first term outweighs the second one.

In combination, proposition 1 states that uncovered interest rate parity (UIP) fails between countries with different foreign ownership shares. A carry strategy that goes long risk-free bonds in countries with low foreign ownership share Q^i and short those with high Q^i delivers positive returns on average. In practice, however, the carry trade is structured based on the observed local currency interest rate differentials. I can show next that ex ante interest rates follow a similar pattern in the model.

Proposition 3: *The interest rate differential observed between two countries is given by*

$$r^h - r^f = \left[\frac{\overline{\Delta d_T} - r^*}{\sigma_T^2} - \left(\frac{(\gamma\tau)^2 + (1-\tau)^2}{\gamma\tau - (1-\tau)} \right) \left(1 - \frac{Q^f + Q^h}{2} \right) \right] (\gamma\tau - (1-\tau))\, \sigma_T^2 (Q^f - Q^h), \quad (23)$$

where r^n is country n's real interest rate in terms of the domestic consumption bundle. Under condition 2, the rate differential is in favor of the country with the lower foreign ownership share.

Proof: Using the fact that $log\ \mathbb{E}(R_P^h) - log\ \mathbb{E}(R_P^f) = r^h - r^f - \Delta\mathbb{E}(s_2^{f,h})$, plug in from above for the bond return differential and the expected change in the real exchange rate. All of the expected bond return differential that is not due to the expected real exchange rate move has to represent the cross-country interest rate differential. Under condition 2, the sum of the coefficients will be positive .

When condition 2 holds, the interest rate differential is going in the same direction as the expected real exchange rate move: When the global investor owns fewer assets in the home country than in the foreign country, we already know that the real exchange rate is expected to appreciate in favor of the home country. Furthermore, proposition 3 states that the domestic risk-free interest rate is higher in countries with lower global investor presence. In combination, both expected real exchange rate appreciation and the observable ex ante interest rate differential make up the bond return differential shown in proposition 2. UIP is hence strongly violated - currencies with higher interest rates dot not just depreciate by too little, they are even expected to appreciate in real terms, the opposite of what UIP would suggest. In this way, the model can generate the forward premium puzzle documented in Fama (1984).

5.4 International Stocks

We can further extend the study of asset prices in this framework to include equity claims.

Definition 2: *Domestic stocks in the traded and the non-traded sector represent claims on the traded and the non-traded good dividend, respectively.*

The economy provides two sorts of equity-like claims: Traded sector stocks describe a claim on the output of the traded good tree, while non-traded sector stocks are claims on the non-traded good tree output. Importantly, the return on non-traded stocks has to be adjusted by the price of the non-traded good, so that the stock's pay-off is $P_N^i D_N^i$, which, given (10), is equal to $\left(\frac{1-\tau}{\tau}\right)\left(\frac{C_T^i}{C_N^i}\right) D_N^i$. Since all non-traded goods are consumed domestically, the price of the non-traded good relative to the traded good is inversely related to its quantity. Finally, the domestic consumption of the non-traded good is exactly equal to the non-traded dividend. This means that the payoff to the non-traded sector stock denominated in traded goods is only a function of traded good consumption - in turn a function of traded good output D_T^i **and** foreign ownership share Q^i. The expected return on a stock in the non-traded sector is then

$$\begin{aligned} log\, \mathbb{E}(R_N^i) = \delta + \gamma\tau\left[(1-Q^i)\overline{\Delta d_T} + Q^i r^*\right] + \gamma(1-\tau)\overline{\Delta d_N} \\ - \frac{(\gamma\tau)^2}{2}(1-Q^i)^2\sigma_T^2 - \frac{(\gamma(1-\tau))^2}{2}\sigma_N^2 \\ + \gamma\tau^2(1-Q^i)^2\sigma_T^2 + \gamma(1-\tau)^2\sigma_N^2. \end{aligned} \tag{24}$$

The last term describes the covariance of the non-traded stock return with the domestic household's pricing kernel, once we take the relative price of non-traded goods into account. For traded stocks, the pay-off is straightforwardly D_T^i, since it is already denominated in traded goods. The expected return on a traded sector stock hence is

$$\begin{aligned} log\ \mathbb{E}(R_T^i) = \delta + \gamma\tau\left[(1-Q^i)\overline{\Delta d_T} + Q^i r^*\right] + \gamma(1-\tau)\overline{\Delta d_N} \\ - \frac{(\gamma\tau)^2}{2}(1-Q^i)^2\sigma_T^2 - \frac{(\gamma(1-\tau))^2}{2}\sigma_N^2 \\ + \gamma\tau^2(1-Q^i)^2\sigma_T^2 + \gamma(1-\tau)^2\sigma_N^2 + Q^i\gamma\tau(1-Q^i)\sigma_T^2. \end{aligned} \tag{25}$$

Now that we know the expected returns on both sectors in the domestic stock market, we can solve for the expected return on the aggregate stock market index. Given the relative weights of traded and non-traded good trees in the local economy (portfolio), the expected return on the index is given by

$$log\ \mathbb{E}(R_{I,t+1}^i) = \left(\frac{D_{N,1}^i}{D_{N,1}^i + D_{T,1}^i}\right) log\ \mathbb{E}(R_N^i) + \left(\frac{D_{T,1}^i}{D_{N,1}^i + D_{T,1}^i}\right) log\ \mathbb{E}(R_T^i).$$

Note that in contrast to the other asset pricing results, this expression requires time notation, since the relative weights of traded and non-traded goods could fluctuate over time. But since equity returns in both sectors share multiple terms, we can solve for the expected index returns explicitly, so that

$$\begin{aligned} log\ \mathbb{E}(R_{I,t+1}^i) = \delta + \gamma\tau\left[(1-Q^i)\overline{\Delta d_T} + Q^i r^*\right] + \gamma(1-\tau)\overline{\Delta d_N} \\ - \frac{(\gamma\tau)^2}{2}(1-Q^i)^2\sigma_T^2 - \frac{(\gamma(1-\tau))^2}{2}\sigma_N^2 \\ + \gamma\tau^2(1-Q^i)^2\sigma_T^2 + \gamma(1-\tau)^2\sigma_N^2 + w_t^i Q^i\gamma\tau(1-Q^i)\sigma_T^2, \end{aligned} \tag{26}$$

where w_t^i captures the market share of the traded good sector in the previous period. In the simple two-period model setting and with the initial assumption that the sector weights are even, we can again compare stock returns across countries.

Propositon 4: *The expected stock index return differential between two countries is given by*

$$\begin{aligned} log\mathbb{E}(R_I^h) - log\mathbb{E}(R_I^f) = -\left[\frac{\overline{\Delta d_T} - r^*}{\sigma_T^2} + \tau - \frac{\gamma\tau}{2} - \left(\frac{1+\gamma\tau-2\tau}{2}\right)(1-Q^f-Q^h)\right] \\ \cdot \gamma\tau\sigma_T^2(Q^h - Q^f) \end{aligned} \tag{27}$$

where log $\mathbb{E}(R_I^j)$ *denotes the log expected return on the country stock market index that has even weights in the non-traded and traded sector stock in country* j*. Under condition 2 and the parameter restrictions outlined in the appendix, returns are higher in the country with lower foreign ownership.*

Furthermore, taking the difference of (25) and (26), I can also solve for the spread between expected returns of traded and non-traded stocks,

$$log\ \mathbb{E}(R_N^i) - log\ \mathbb{E}(R_T^i) = -Q^i\gamma\tau(1-Q^i)\sigma_T^2, \tag{28}$$

which is decreasing in foreign ownership share Q^i if $Q^i \leq \frac{1}{2}$.[24] If this condition is met, then we can compare cross-country differentials in returns on this long-short portfolio in the following way:

Propositon 5: *The difference in the log expected return spread between traded and non-traded sector stocks of two countries is given by:*

$$log\ \mathbb{E}(R_S^h) - log\ \mathbb{E}(R_S^f) = \gamma\tau\sigma_T^2\left[1-(Q^f+Q^h)\right](Q^f-Q^h), \tag{29}$$

where $log\ \mathbb{E}(R_S^j)$ *denotes the log expected return on a portfolio that is long the non-traded sector stock and short the traded sector stock in country* j*. Under condition 2 and if* $Q^f + Q^h < 1$*, the return differential is in favor of the country with lower foreign ownership.*

Proof: Take the difference of equation (27) for countries h and f, and rearrange. If both Q^f and Q^h are less than $\frac{1}{2}$, the return differential will be in favor of the country with the lower foreign ownership share.

The expected return differential between stocks in the non-traded and the traded sector decreases with foreign ownership. The differential includes a non-linear term, so it decreases faster (becomes more negative) the more domestic assets are owned by foreigners. The source of the return differential can again be traced back to the extent of the local agent's tradable consumption diversification. If there is little diversification, domestic tradable consumption has a high variance. This in turn matters for the price of the non-tradable good, whose variance increases in lockstep with tradable

[24]This assumption, i.e. that foreigners hold a claim on at most half of all traded good production in an economy, is not overly restrictive. While in the data, a number of countries have gross portfolio liabilities of above 50 of domestic GDP, however this does not take into account valuation levels. In the case where I can directly observe valuation - equity portfolio liabilities relative to the domestic stock market - there are only three countries that show levels above 50 percent for some part of the sample: Hungary, and the United Kingom and Switzerland. At least for the latter two countries, this number is most likely inflated by the way international mutual fund holdings are characterized in the IMF CPIS survey (see the discussion in the robustness section of the empirical part for more detail).

consumption. As a result, the riskiness of shares in the non-traded goods-producing tree is directly related to the extent of the domestic household's traded income diversification. The differential arises from the differences in how diversification affects output risk - linear in the case of the traded good tree, and non-linear for the non-traded tree.

6 Conclusion

This paper documents a strong empirical relationship between cross-border gross portfolio holdings and international asset return differentials: When foreigners hold fewer assets in a particular country, currency returns and interest rates are consistently higher, and so are aggregate stock returns, as well as equity returns in non-traded sector relative to traded sectors. This insight is statistically and economically significant, and robust to other proposed drivers of return differentials. The fact that returns and foreigners' gross capital allocations are inversely related is a puzzle for standard models of international return differentials, both in complete and incomplete markets.

Further empirical analysis establishes that frictions in the domestic capital market, in particular corporate-level agency problems, can jointly explain variation in foreign ownership rates as well as return differentials in the whole set of assets, even those not directly exposed to them. This is consistent with previous evidence in the literature on home bias but a new insight with respect to international return differentials.

The newly established empirical relationship has substantial economic significance: Using a portfolio sorting technique, investing in countries according to the severity of their agency frictions produces strategies with very high Sharpe ratios across equity and currency markets, which are as if not more effective than the classic carry trade.

In order to make sense of the connection between home bias, asset return differentials and agency frictions, I turn to a standard international asset pricing model and add a capital market friction. This gives rise to a simple mechanism, where corporate-level agency frictions limit foreign ownership of domestic assets. As a result, local investors are imperfectly diversified and more heavily exposed to the domestic economy, which - when the local agent prices the asset - gives rise to additional risk premia in a broad set of assets. The mechanism is supported by empirical evidence that countries with stronger frictions (as captured by a lower investable share of the domestic stock market) have consumption processes that are more directly exposed to local output shocks, even when global shocks are accounted for.

In combination, the set of theoretical and empirical results presented in this paper suggest that the assumption of complete markets common in international asset pricing models is less than inocuous, and that a deeper concern for variation in international portfolio allocation is warranted. In this framework, further study of the investment decisions by large international mutual funds, such as those outlined in Camanho, Hau and Rey (2018), or Maggiori, Neiman and Schreger (2018), should be of particular interest for general equilibrium models of international asset pricing.

Finally, this paper provides a new perspective on international gross capital stocks and flows. While foreign capital flows have most recently been the target of much scepticism from policy makers, the results in this paper emphasize the simple insight that foreign asset holdings - at least in their balanced form - provide an important service by allowing for diversification and global risk sharing. From a policy perspective, this suggests a stronger focus on making channels for international capital flows wider, rather than narrower, and to do so by focusing on improving institutional capital market design and reducing frictions for outside investors.

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Figure 2-1: Portfolio Liabilities (CPIS) and Interpolated using Flow Data for Australia

Notes: Gross portfolio liabilities to foreigners as % of GDP, 2001 - 2017 for Australia, original data from CPIS and with quarterly updated using portfolio flows for interpolation (no forward-looking information used).

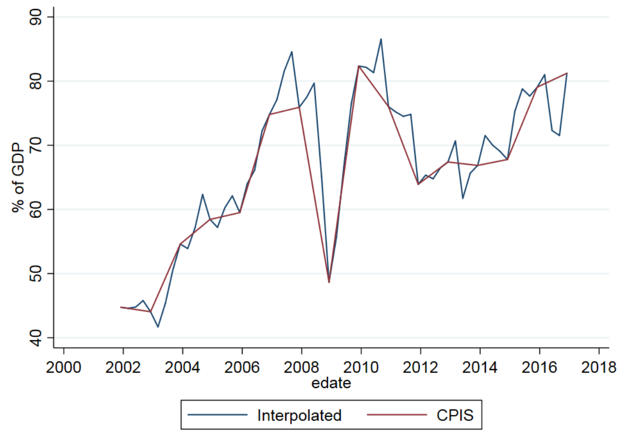


Figure 2-2: Portfolio Liabilities to Foreigners vs. Stock Market Investable Share

Notes: Unconditional scatter plots of gross portfolio liabilities to foreigners (sample mean, 2002-2017) to the internationally investable share of the local stock market, defined as the market capitalization of the country's MSCI index relative to the country's total stock market capitalization.

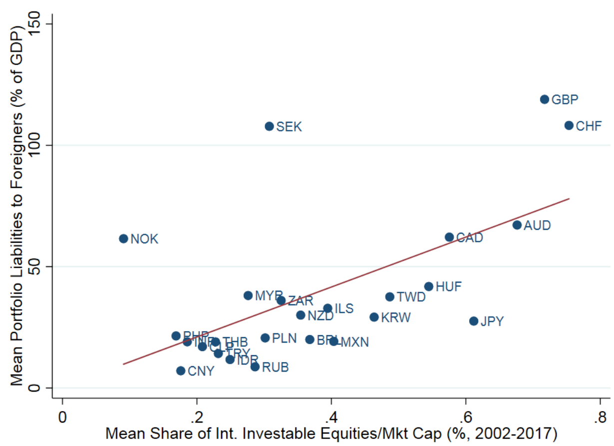


Figure 2-3: Cumulative Factor Performance for INV and HML

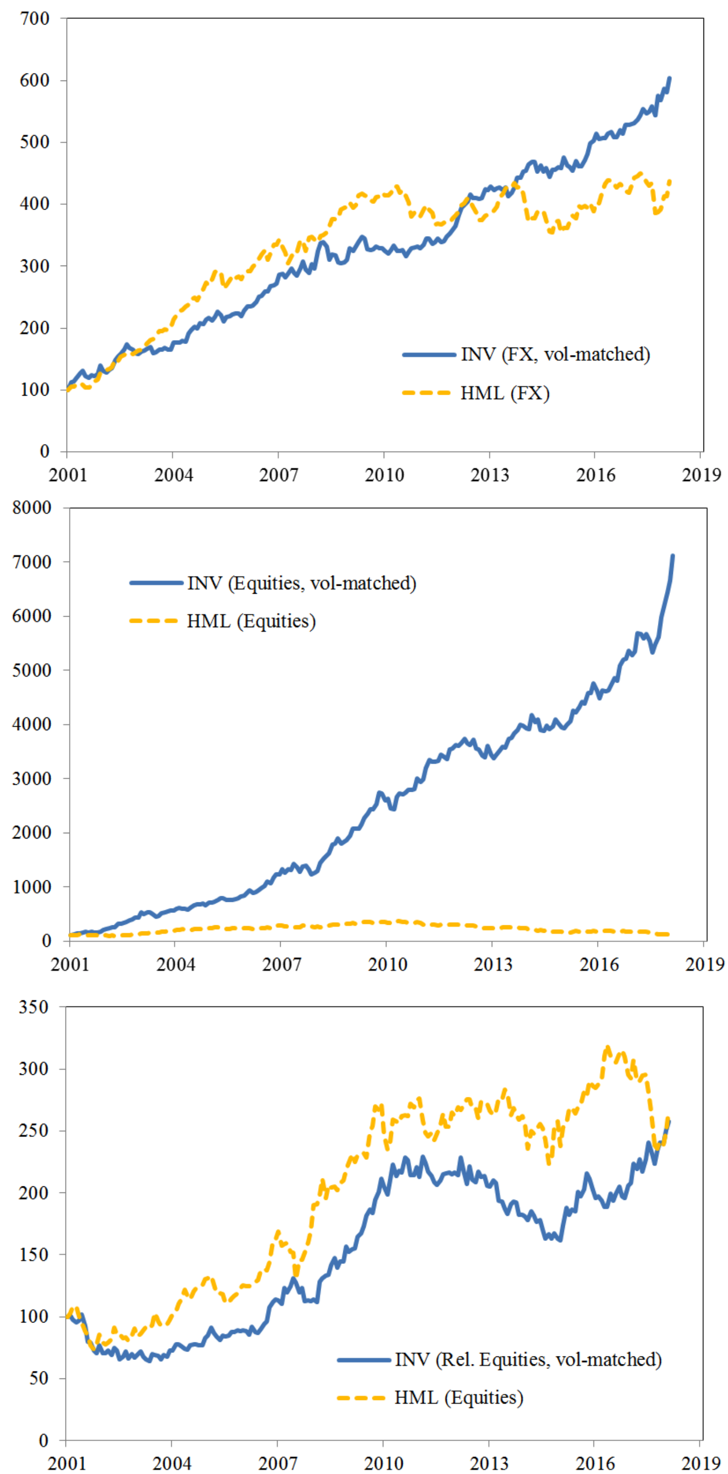


Figure 2-4: Consumption Betas vs. Investable Share

Notes: Unconditional scatter plot of estimated coefficients from the regression of a country's year-on-year real consumption growth (PPP) on country real GDP growth (PPP) from 2001 to 2014, against the average investable share of the same country over the same period. The sample of countries excludes Norway because of its negative beta coefficient, due to the fact that large parts of Norway's GDP comes from oil production, whose revenues are to a large extent kept in a Sovereign Wealth Fund and in assets from outside of the country.

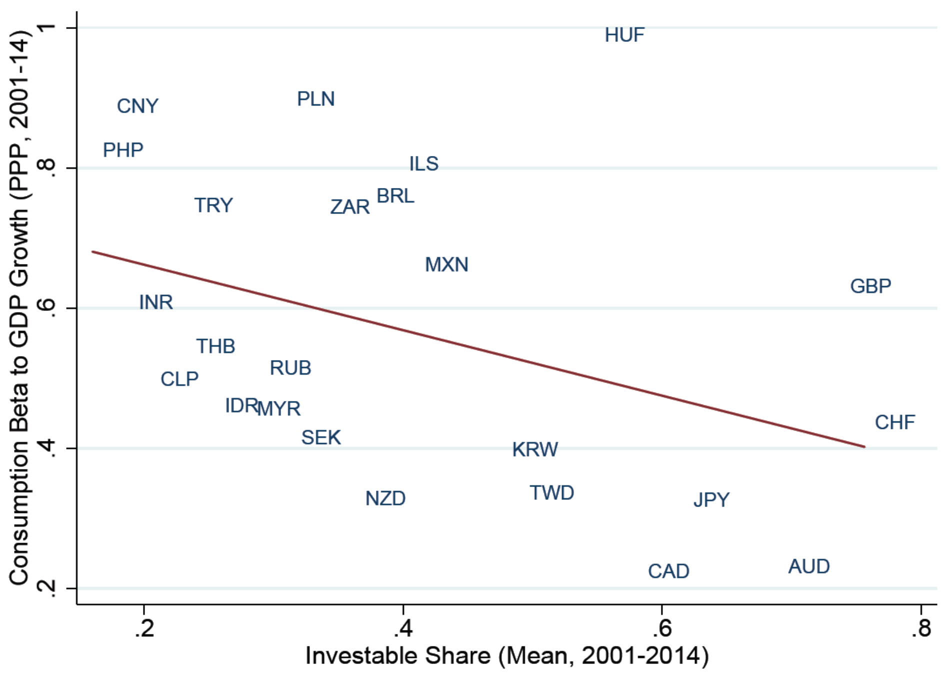


Table 2-1: Asset Returns and Foreign Ownership

Notes: Pooled OLS regressions with robust standard errors in parantheses, clustered by country. The dependent variables are quarterly USD returns on 3-month currency forwards (1), the MSCI country index (3), and the relative return on equities in the non-traded sector less the returns on the traded sector (4), while column (2) uses the forward premium implied by 3-month currency forwards against the USD. The sample consists of 26 major advanced and emerging economies with their own currency. I exclude countries with pegged nominal exchange rates to the USD and the US (as the base country) and the Euro area because CPIS does not provide a consolidated account. Portfolio liabilities measures total debt and equity security liabilites to foreigners, scaled by GDP, as captured on a claims-implied basis in the IMF CPIS report at the end of the year, and updated quarterly with flow data from the IMF's BPM6 accounts.

	(1)	*(2)*	*(3)*	*(4)*
	FX	*Forward Premium (3m)*	*Equity Return (USD)*	*Non-traded Sector Stock Premium*
Portfolio Liabilities/GDP	**-0.030*** **	**-0.052*** **	**-0.040** **	**-0.067*** **
	(0.008)	(0.014)	(0.018)	(0.016)
Constant	**11.860** **	**8.865*** **	**30.870** **	**-31.426* **
	(5.205)	(2.901)	(11.641)	(17.358)
N	1521	1524	1353	1421
R-squared	0.428	0.213	0.642	0.234
Time fixed effects	*yes*	*yes*	*yes*	*yes*

Robust country-clustered SEs in parantheses

** p<0.1 ** p<0.05 *** p<0.01*

Table 2-2: Currency Premia (Excess Bond Returns)

Notes: Pooled OLS regressions with robust standard errors in parantheses, clustered by country. Dependent variable is the annualized 3-month realized log excess return on the domestic country's currency forward against the USD. The sample consists of 26 major advanced and emerging economies with their own currency. I exclude countries with pegged nominal exchange rates to the USD and the US (as the base country) and the Euro area because CPIS does not provide a consolidated account. Portfolio liabilities measures total debt and equity security liabilites to foreigners, scaled by GDP, as captured on a claims-implied basis in the IMF CPIS report at the end of the year, and updated quarterly with flow data from the IMF's BPM6 accounts. GDP share captures the share of global GDP (USD) accounted for by the respective country. FX volatility is computed as the standard deviation in the monthly change in the nominal exchange rate against the USD over a rolling 1-year window. NIIP/GDP is the net international investment positon relative to GDP from the IMF's IFS database.

	(1)	*(2)*	*(3)*	*(4)*	*(5)*
	Total FX Return (QoQ, vs 3m USD Fwd, annl. %)				
Portfolio Liabilities/GDP	**-0.034*** **	**-0.034*** **	**-0.029*** **	**-0.030** **	**-0.025** **
	(0.009)	(0.009)	(0.010)	(0.012)	(0.011)
GDP Share		**-0.209**			**0.157**
(Hassan, 2013)		(0.281)			(0.271)
FX Volatility (1Y trailing)			**182.3*** **		**123.3*** **
			(53.125)		(40.717)
NIIP/GDP				**-0.004**	**-0.000**
(Della Corte et al. 2016)				(0.007)	(0.008)
Constant	**11.950** **	**12.306** **	**5.627**	**4.380**	**0.672**
	(5.223)	(5.219)	(3.606)	(5.211)	(5.258)
N	1451	1451	1423	1023	1006
R-squared	0.426	0.426	0.434	0.489	0.489
Time fixed effects	*yes*	*yes*	*yes*	*yes*	*yes*

Robust country-clustered SEs in parantheses

** p<0.1 ** p<0.05 *** p<0.01*

Table 2-3: Interest Rate Differentials (Forward Premia)

Notes: Pooled OLS regressions with robust standard errors in parantheses, clustered by country. The dependent variable is the annualized percent difference between current spot and the 3-month forward point of the domestic country's currency against the USD. The sample consists of 26 major advanced and emerging economies with their own currency. I exclude countries with pegged nominal exchange rates to the USD and the US (as the base country) and the Euro area because CPIS does not provide a consolidated account. Portfolio liabilities measures total debt and equity security liabilites to foreigners, scaled by GDP, as captured on a claims-implied basis in the IMF CPIS report at the end of the year, and updated quarterly with flow data from the IMF's BPM6 accounts. GDP share captures the share of global GDP (USD) accounted for by the respective country. FX volatility is computed as the standard deviation in the monthly change in the nominal exchange rate against the USD over a rolling 1-year window. NIIP/GDP is the net international investment positon relative to GDP from the IMF's IFS database.

	(1)	*(2)*	*(3)*	*(4)*	*(5)*
	Forward Premium (3-month forward vs. current spot, annl. %)				
Portfolio Liabilities/GDP	**-0.053*****	**-0.053*****	**-0.052*****	**-0.040*****	**-0.038*****
	(0.014)	(0.016)	(0.014)	(0.012)	(0.011)
GDP Share		**-0.300**			**0.150**
(Hassan, 2013)		(0.232)			(0.137)
FX Volatility (1Y trailing)			**148.066*****		**108.019*****
			(46.709)		(22.444)
NIIP/GDP				**-0.017****	**-0.013****
(Della Corte et al. 2016)				(0.006)	(0.005)
Constant	**8.878*****	**9.388*****	**3.812****	**5.689****	**2.489**
	(2.898)	(2.971)	(1.415)	(2.117)	(1.491)
N	1451	1451	1423	1023	1006
R-squared	0.210	0.228	0.357	0.334	0.439
Time fixed effects	*yes*	*yes*	*yes*	*yes*	*yes*

Robust country-clustered SEs in parantheses

** p<0.1 ** p<0.05 *** p<0.01*

Table 2-4: International Stock Index Returns

Notes: Pooled OLS regressions with robust standard errors in parantheses, clustered by country. Dependent variable is the annualized 3-month realized log excess return on the domestic country's MSCI index in USD. The sample consists of 26 major advanced and emerging economies with their own currency. I exclude countries with pegged nominal exchange rates to the USD and the US (as the base country) and the Euro area because CPIS does not provide a consolidated account. Portfolio liabilities measures total debt and equity security liabilites to foreigners, scaled by GDP, as captured on a claims-implied basis in the IMF CPIS report at the end of the year, and updated quarterly with flow data from the IMF's BPM6 accounts. GDP share captures the share of global GDP (USD) accounted for by the respective country. FX volatility is computed as the standard deviation in the monthly change in the nominal exchange rate against the USD over a rolling 1-year window. NIIP/GDP is the net international investment positon relative to GDP from the IMF's IFS database.

	(1)	*(2)*	*(3)*	*(4)*	*(5)*
	Excess Stock Return (USD, QoQ, annl. %)				
Portfolio Liabilities/GDP	**-0.040****	**-0.041****	**-0.038***	**-0.020**	**-0.016**
	(0.018)	(0.017)	(0.020)	(0.019)	(0.021)
GDP Share		**-0.520**			**0.301**
(Hassan, 2013)		(0.396)			(0.357)
FX Volatility (1Y trailing)			**121.571**		**232.945*****
			(73.008)		(64.823)
NIIP/GDP				**0.013**	**0.024**
(Della Corte et al. 2016)				(0.013)	(0.018)
Constant	**30.870****	**31.742****	**26.661****	**17.044**	**10.229**
	(11.641)	(11.751)	(12.097)	(16.297)	(17.060)
N	1353	1353	1325	935	918
R-squared	0.642	0.643	0.635	0.651	0.651
Time fixed effects	*yes*	*yes*	*yes*	*yes*	*yes*

Robust country-clustered SEs in parantheses

** p<0.1 ** p<0.05 *** p<0.01*

Table 2-5: Relative Returns on Equities in the Non-traded vs. Traded Sector

Notes: Pooled OLS regressions with robust standard errors in parantheses, clustered by country. Dependent variable is the difference between quarterly log returns on stocks in the non-traded sector (value-weighted aggregate of MSCI healthcare and financials indices) and the traded sector (value-weighted aggregate of MSCI materials and industrials indices) in USD. The sample consists of 26 major advanced and emerging economies with their own currency. I exclude countries with pegged nominal exchange rates to the USD and the US (as the base country) and the Euro area because CPIS does not provide a consolidated account. Portfolio liabilities measures total debt and equity security liabilites to foreigners, scaled by GDP, as captured on a claims-implied basis in the IMF CPIS report at the end of the year, and updated quarterly with flow data from the IMF's BPM6 accounts. GDP share captures the share of global GDP (USD) accounted for by the respective country. FX volatility is computed as the standard deviation in the monthly change in the nominal exchange rate against the USD over a rolling 1-year window. NIIP/GDP is the net international investment positon relative to GDP from the IMF's IFS database.

	(1)	*(2)*	*(3)*	*(4)*	*(5)*
	Excess Equity Return on Non-tradables vs. Tradables Equity Return (QoQ, USD, annl. %)				
Portfolio Liabilities/GDP	**-0.080*** **	**-0.080*** **	**-0.078*** **	**-0.071*** **	**-0.060*** **
	(0.016)	(0.016)	(0.018)	(0.017)	(0.017)
GDP Share		**-0.037**			**0.232**
(Hassan, 2013)		(0.403)			(0.349)
FX Volatility (1Y trailing)			**98.616**		**146.179**
			(121.044)		(115.457)
NIIP/GDP				**0.008**	**0.009**
(Della Corte et al. 2016)				(0.018)	(0.018)
Constant	**-31.089***	**-31.023***	**-34.555***	**-27.779**	**-32.495**
	(17.366)	(17.462)	(19.580)	(28.408)	(29.277)
N	1355	1355	1328	949	932
R-squared	0.242	0.242	0.246	0.280	0.285
Time fixed effects	*yes*	*yes*	*yes*	*yes*	*yes*

Robust country-clustered SEs in parantheses

** p<0.1 ** p<0.05 *** p<0.01*

Table 2-6: Foreign Ownership and the Investable Share

Notes: Pooled OLS regressions with robust standard errors in parantheses, clustered by country. The dependent variable is the sum of equity and debt portfolio liabilities to foreigners, scaled by GDP from the IMF's CPIS survey at the end of the year, and updated quarterly with flow data from the IMF's BPM6 accounts. The sample consists of 26 major advanced and emerging economies with their own currency. The investable share is constructed by taking the total market capitalization of a country's MSCI index, and dividing it by its total stock market capitalization.

	(1)
	Portfolio Liabilities/GDP
Investable Share	**103.1*** **
	(31.11)
Constant	**-24.68***
	(13.79)
N	1359
R-squared	0.39
Time fixed effects	yes

Robust country-clustered SEs in parantheses

** p<0.1 ** p<0.05 *** p<0.01*

Table 2-7: Asset Returns and the Investable Share

Notes: Pooled OLS regressions with robust standard errors in parantheses, clustered by country. The dependent variables are quarterly USD returns on 3-month currency forwards (1), the MSCI country index (3), and the relative return on equities in the non-traded sector less the returns on the traded sector (4), while column (2) uses the forward premium implied by 3-month currency forwards against the USD. The sample consists of 26 major advanced and emerging economies with their own currency. Portfolio liabilities to GDP are instrumented by the investable share (see text for a detailed description).

	(1)	*(2)*	*(3)*	*(4)*
	FX	*Forward Premium (3m)*	*Equity Return (USD)*	*Non-traded Sector Stock Premium*
Portfolio Liabilities/GDP	**-0.072****	**-0.079****	**-0.181****	**-0.115*****
IV: Investable Share	(0.029)	(0.033)	(0.076)	(0.041)
N	1521	1524	1353	1421
R-squared	-0.003	0.091	-0.018	0.002
Time fixed effects	*yes*	*yes*	*yes*	*yes*

Robust country-clustered SEs in parantheses

** p<0.1 ** p<0.05 *** p<0.01*

Table 2-8: Portfolio Sorting

Notes: Summary statistics of currency, equity and relative equity sector (long nontraded vs. short traded sector) portfolios, sorted on country investable share, and forward premium (vs. the USD) on a monthly basis from 2001 to 2017. Each month, countries are ranked on the respective sorting criteria and placed into 5 portfolios with equal weights. Forward spread and returns (mean, standard deviation and Sharpe ratio) are annualized percentage return figures. The last column in each block shows the difference between the low (high) and the high (low) portfolio sorted on the investable share or forward premium, i.e. a strategy that goes long portfolio 1 and short portfolio 5. The descriptive statistics describe the mean value for each variable in each portfolio. ***, **, and * denote significance of based on Newey-West standard errors.

	Investable Share						***Forward Premium***					
	P1	**P2**	**P3**	**P4**	**P5**	**INV**	**P1**	**P2**	**P3**	**P4**	**P5**	**HML**
Characteristics												
Fwd Prem (t, 1m,%)	0.41	0.36	0.37	0.19	0.00	0.41	1.08	0.43	0.19	0.02	-0.26	1.34
Investable Shr (t, %)	0.17	0.25	0.33	0.46	0.67	-0.51	0.30	0.33	0.41	0.41	0.46	-0.17
Currencies												
mean (%)	7.7	2.2	2.7	-0.2	0.4	7.2	7.4	3.7	2.2	1.3	-2.0	9.5
fx (%)	2.6	-2.1	-1.8	-2.4	0.4	2.1	-5.7	-1.5	0.0	1.1	1.1	-6.8
Sharpe	**1.04**	**0.26**	**0.26**	**-0.02**	**0.05**	**1.18*****	**0.64**	**0.39**	**0.30**	**0.19**	**-0.26**	**0.99*****
std	7.3	8.4	10.1	8.8	7.5	6.1	11.6	9.4	7.5	6.8	7.6	9.6
skew	-0.4	-0.6	-1.2	-0.9	-0.2	0.4	-0.9	-1.3	-0.7	-0.2	-1.2	-0.5
kurt	3.1	1.8	3.3	2.4	1.1	1.7	2.0	6.7	1.6	0.7	7.5	2.3
mdd (%)	-9.4	-10.2	-12.2	-10.3	-8.3	-4.1	-13.8	-15.5	-9.0	-6.3	-13.7	-11.1
Equities												
mean (%)	33.5	14.8	13.8	5.9	6.6	25.4	14.9	16.2	13.4	13.4	10.9	3.7
Sharpe	**1.44**	**0.66**	**0.65**	**0.29**	**0.42**	**1.77*****	**0.55**	**0.72**	**0.73**	**0.79**	**0.60**	**0.22**
std	23.3	22.5	21.3	20.4	15.5	14.4	27.1	22.5	18.3	16.9	18.3	16.7
skew	0.0	-0.3	-0.8	-0.6	-0.7	0.9	-0.2	-0.5	-0.3	-0.7	-0.8	0.5
kurt	2.7	1.9	3.1	2.3	2.1	3.1	1.0	3.5	1.6	2.0	4.2	1.2
mdd (%)	-26.4	-27.0	-30.0	-27.7	-19.7	-9.2	-31.4	-29.7	-20.9	-21.5	-27.6	-11.9
Relative Equities												
mean (%)	1.9	1.8	-0.2	-0.2	-3.6	5.7	4.3	2.1	0.1	-2.7	-2.6	7.1
Sharpe	**0.18**	**0.15**	**-0.01**	**-0.02**	**-0.31**	**0.45****	**0.30**	**0.17**	**0.01**	**-0.23**	**-0.23**	**0.47**
std	10.6	12.6	15.0	11.7	11.3	12.5	14.5	12.3	11.5	11.8	11.4	15.0
skew	-0.1	0.9	0.1	0.1	0.3	0.3	0.1	0.4	0.0	-0.2	-0.4	-0.1
kurt	-0.1	5.5	2.7	1.6	2.2	0.05	2.3	0.8	0.9	0.6	2.0	0.9
mdd (%)	-8.3	-11.5	-16.0	-11.0	-10.8	-7.4	-14.9	-8.7	-9.4	-10.5	-14.3	-14.1

Table 2-9: Aggregate Factor Characteristics

Notes: Summary statistics for INV and HML factors for different sample periods for all three asset classes. Factors are constructed from individual portfolios of assets based on the described sorting variables (investable share and forward premium, respectively) as described in the text.

	FX		**Equities**		**Rel. Equities**	
	INV	*HML*	*INV*	*HML*	*INV*	*HML*
2001-2018						
mean	7.24	9.53	25.41	3.67	5.69	7.11
Sharpe	**1.18**	**0.99**	**1.77**	**0.22**	**0.45**	**0.47**
2005-2018						
mean	5.47	3.95	17.06	-2.98	7.68	6.56
Sharpe	**1.08**	**0.42**	**1.57**	**-0.20**	**0.67**	**0.46**
2010-2018						
mean	4.62	1.54	13.03	-7.48	5.49	2.45
Sharpe	**1.10**	**0.17**	**1.44**	**-0.53**	**0.52**	**0.19**

Table 2-10: Real Consumption Growth Sensitivity to Local Output Growth

Notes: Pooled OLS regression of country real consumption growth (PPP) on contemporaneous domestic real GDP growth (PPP), country investable share, and their interaction. The regression also includes country effects, to account for differences in mean growth consumption growth rates, and time-fixed effects, to account for aggregate global shocks. Consumption and output data are sourced from the Penn World tables, and the sample period is 2001-2014.

	(1)
	Real Consumption Growth (PPP)
Investable Share	**1.469**
	(0.79)
Real GDP Growth (PPP)	**0.685*****
	(10.85)
Investable Share x Real GDP Growth	**-0.295***
	(-1.79)
N	319
R-sq	0.750
Time fixed effects	*yes*
Country fixed effects	*yes*

T-statistics in parentheses

* p<0.1 ** p<0.05 *** p<0.01

A Robustness

In order to further confirm the reliabilty of the results highlighted above, I now run a number of robustness checks. First, I consider the independent variable, the measure of foreign investor participation, before considering variations in the sample and other asset pricing factors.

A.1 Other measures of gross portfolio liabilities and gross portfolio assets

As discussed above, I use a country's gross portfolio liabilities to foreigners as a percentage of GDP from the CPIS as my preferred measure of the extent to which foreign investors hold domestic assets. This variable is chosen based on two key assumptions: One, that it is the most accurate measure of true foreign ownership of claims to domestic output, and two, that it also adequately approximates a country's ownership of claims to foreign output. I can test both of these assumptions by replicating my main results with alternative data on aggregate gross foreign liabilities (both total and portfolio assets) and gross domestic holdings of foreign assets (also in total and specifically for portfolio assets) from the IMF's International Investment Position (IIP) data.

The results remain highly significant, even when I use foreign assets rather than liabilities, and when total rather than just portfolio claims are considered (as the sole exception, the alternative variables are at times insignificant for equity index returns). Even though assets and liabilities are clearly fundamentally different, this result is not surprising when taking into account that first, the literature on gross capital flows has shown convincingly that gross capital in- and outflows are mostly offsetting (Broner et al. 2013), and that second, controlling for the **net** IIP in the regression results does not change my results. This cross-check again highlights the importance of *gross* rather than *net* capital flows for international return differentials, so far a less well-studied component in the literature.

A.2 Including currency pegs

Next, I consider if particular changes in the sample could invalidate my results. First, I consider the full set of countries in my sample, including time periods and countries that have pegged nominal exchange rates. This increases the total number of observations by more than 10% but does not change the significance of the coefficients in the baseline regression. In fact, coefficients actually increase, especially for bond returns and interest rate differentials.

A.3 Sample variations

To ensure that results are not driven by a small set of observations or outliers, I re-run both the baseline and the IV regressions while dropping one country or one year at a time. The results are highly robust to this test, as coefficients generally preserve size and significance in all sample specification in the IV setting using the investable share. Using observed portfolio liabilities directly, results are also stable throughout all sample permutations, except for aggregate equity returns. The coefficient on portfolio liabilities becomes borderline insignificant when all UK observations are dropped, and when observations from 2003, 2005, 2007 or 2009 are dropped, respectively. However, as mentioned above, using the investable share as an instrument preserves the regression results' robustness to these sample changes.

A.4 Controlling for global asset pricing factors

Lastly, of particular interest in a pure asset pricing framework, I check if the relationship that I uncover between asset returns and foreign ownership is robust to controlling for known asset pricing factors. I proceed in two stages: First, I regress each asset return individually on the contemporaneous international factor returns (market, value, and momentum) from Asness, Moskowitz and Pedersen (2013). Second, I use the residual from this regression, now orthogonalized to the identified international factors, as the dependent variable in my baseline regression with foreign portfolio liabilities, instrumented by the investable share. The coefficients shrink somewhat relative to the original regression, and the effect is particularly noticeable for equity returns, but results remain strongly negative and statistically significant. Therefore, returns on currencies, equity indices and relative returns on equity sectors contain a systematic component that is aligned with the cross-country variation in foreign ownership and that is not already subsumed by previously identified asset market factors.

B Theoretical results

B.1 Proof of Proposition 1

First, I establish that for the global investor and the local agent, the exchange of local shares for global bonds is mutually beneficial. For the global investor, this is straightforward from risk neutrality and the fact that the mean dividend growth rate, the net return on a unit of the tree, exceeds the net global interest rate r^*, which serves as the funding rate for the global investor.

In turn, the local agent will agree to the transaction if the interest rate on the global bond is at least as high as the market-market clearing return on a hypothetical local risk-free bond that pays out only in traded goods. Given some exogenously given r^* and some Q^i, we can price this local traded-good bond ("synthetic") using the local agent's Euler equation:

$$\begin{aligned} r^i_{syn} = ln\ \mathbb{E}(R^i_{syn}) =& \delta + \gamma\tau((1-Q^i)\overline{\Delta d_T} + r^* Q^i) + \gamma(1-\tau)\overline{\Delta d_N} \\ & - \gamma\tau(\frac{\gamma\tau}{2} + (1-\tau))(1-Q^i)^2\sigma_T^2 + \gamma(1-\tau)^2(1-\frac{\gamma}{2})\sigma_N^2. \end{aligned}$$

Since the synthetic traded good bond return is a function of foreign ownership Q^i, I next take the derivative of the synthetic rate with respect to Q^i, in order to determine the maximum possible interest rate:

$$\frac{\partial r^i_{syn}}{\partial Q^i} = (\overline{\Delta d_T} - r^*)\gamma\tau + \gamma\tau(\gamma\tau + 2(1-\tau))(1-Q^i)\sigma_T^2. \tag{30}$$

Setting this expression to zero, I find that the synthetic interest rate is maximized in Q^i when

$$Q^i = 1 - \frac{1}{\gamma\tau + 2(1-\tau)}\left(\frac{\overline{\Delta d_T} - r^*}{\sigma_T^2}\right), \tag{31}$$

since the second derviate is negative. Under conditon 2, the paramters of the model are restricted so that the second term will be larger than 1, so that the synthetic interest rate is maximized at some negative amount for Q^i. Since the minimum possible value for foreign ownership is 0, this means that the highest possible value for the synthetic interest rate is achieved at $Q^i = 0$ and declines from there:

$$\begin{aligned} r^i_{syn}(0) =& \delta + \gamma\tau\overline{\Delta d_T} + \gamma(1-\tau)\overline{\Delta d_N} \\ & - \gamma\tau(\frac{\gamma\tau}{2} + (1-\tau))\sigma_T^2 + \gamma(1-\tau)^2(1-\frac{\gamma}{2})\sigma_N^2. \end{aligned}$$

Under this assumption, both the global investor and the local agent will want to trade global bonds for local tree shares in the largest amount possible. However, we know from the local operator's problem that for foreign ownership shares $Q^i > \phi^i$, the operator will always choose to report a complete loss to the global investor and instead simply occur the legal penalty rate, leaving the global investor's true gross return at 0. Therefore, the global investor will choose to purchase just as many shares so that the local operator is indifferent between truthfully reporting returns and lieing.

B.2 Parameter restrictions

In order for the model to have the discussed implications for asset returns, I now collect the required parameter restrictions for each result, and discuss their compatibility.

1 The return differential will be in favor of the country with lower foreign ownership share if

$$\frac{\overline{\Delta d_T} - r^*}{\sigma_T^2} > \gamma\tau\left(1 - \frac{Q^h + Q^f}{2}\right).$$

2 The country with lower foreign ownership of domestic assets will have a higher interest rate if

$$\frac{\overline{\Delta d_T} - r^*}{\sigma_T^2} > \frac{(\gamma\tau)^2 + (1-\tau)^2}{\gamma\tau - (1-\tau)}\left(1 - \frac{Q^h + Q^f}{2}\right).$$

In order for these restrictions to apply for any values of Q^i, I collapse the final term in condition 1 and 2 to 1. Since we assume that $\tau < 0.5$ and $\gamma > \frac{1-\tau}{\tau}$, condition 1 is always met when condition 2 is (as long as the left hand side is positive, which is assumed above).

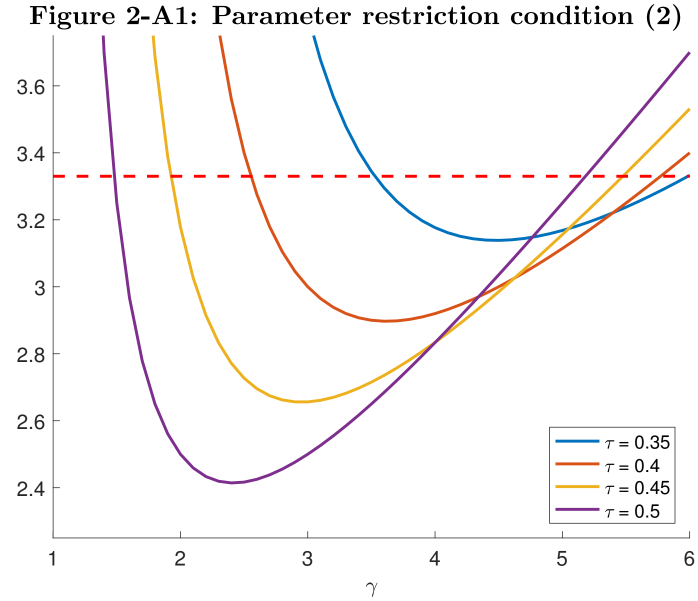
This leaves one condition for the joint parameter space: The differential between the mean of traded good output growth and the global bond interest rate, scaled by the variance (not the standard deviation, or volatility) of the traded good output growth, needs to be larger than a combination of the household's risk aversion γ and relative weight on traded goods in the consumption bundle τ:

$$\frac{\overline{\Delta d_T} - r^*}{\sigma_T^2} > \frac{(\gamma\tau)^2 + (1-\tau)^2}{\gamma\tau - (1-\tau)}. \tag{32}$$

I now explore this condition numerically. The left-hand side can be anchored by the data, since it represents the Sharpe ratio of holding an equity portfolio, scaled (a second time) by its volatility. Taking global equities as a reference point, a Sharpe ratio of around 0.5 with a volatility of 0.2 results in a total value of 2.5. If we take US equity volatility of 15 percent as a reference point, the number rises to 3.33. The graphs below illustrate the conditions relative to those cut-offs (the latter is marked by the dotted line) for different values of risk aversion γ for each value of consumption weight τ.

As visible in figure A1, interest rate differentials show the expected pattern for a reasonable set of values for risk aversion and household preferences for the traded good. On the high end, when households put even weights on traded and non-traded goods, only risk aversion parameter values $\gamma > 5$ lead to a violation of the condition. When consumption preferences are more heavily weighted towards the non-traded good, then the condition is violated only for high levels of γ. However, given the non-linear structure of the condition, the admissable range also shrinks from the bottom as consumption home bias increases. The less the domestic household cares about the non-traded good, the more risk aversion is needed for the condition to hold. The upper limit for $\gamma < 3\left(\frac{1-\tau}{\tau}\right)$ can also be more restrictive here for higher values of τ.

Figure 2-A1: Parameter restriction condition (2)



In conclusion, for reasonable parameter value combinations, the model exhibits the described characteristics, though there remains the need for caution if the model was applied with more extreme parameterization, in particular with respect to high levels of risk aversion, or strong forms of consumption home bias.

B.3 Extension: Joint asset pricing with global investors

In the baseline model, a helpful simplifying assumption is that the global investor, always offers one unit of the global bond in exchange for one unit of the local tree. Under condition 1, this trade is always beneficial to both participants (markets clear), and it allows for a streamlined comparison between asset returns in two countries with different foreign ownership shares. However, in the interest of a more realistic modeling of international financial transactions, I now relax this assumption and instead let the global investor purchase local assets at the true market-clearing price in the domestic market. As before, the agency friction determines the share of the domestic tree that can be owned by the global investor, but now the market determines the price, and hence the effective global bond return that the local agent receives in exchange. The payout of traded goods to the local agent coming from her bond position that she receives in exchange for giving up Q^i units of the local tree is then defined as

$$r^i_{syn} Q^i = r^* \frac{Q^i}{K^i}, \tag{33}$$

where K^i denotes the "exchange rate" between tree share and global bond, i.e. the relative price. What determines the price K^i? Since the resulting effective rate of return on the global bond needs to make the local agent indifferent between a marginal unit of the global bond or the local tree, r^i_{syn} is in practice the required rate of return on a bond that pays out one unit of the traded good with certainty if it was offered in the domestic economy (hence called "synthetic"). Given some Q^i and r^*, solving for the synthetic rate is straightforward, as given in the appendix:

$$\begin{aligned} r^i_{syn} = ln\, \mathbb{E}(R^i_{syn}) = &\delta + \gamma\tau((1-Q^i)\overline{\Delta d_T} + r^* Q^i) + \gamma(1-\tau)\overline{\Delta d_N} \\ &- \gamma\tau(\frac{\gamma\tau}{2} + (1-\tau))(1-Q^i)^2\sigma_T^2 + \gamma(1-\tau)^2(1-\frac{\gamma}{2})\sigma_N^2. \end{aligned}$$

In the case that r^* is no longer exogenous and replaced by r^i_{syn}, this expression does not have a simple analytical expression. However, we know from the proof of proposition 1 that the market clearing synthetic rate is decreasing in foreign ownership Q^i if the household receives the exogenous return r^* on its bond holdings. Under the following additional restriction on the paramter space of the model, this is also true with endogenous returns.

Condition 2b: *The parameters of the model are confined to be such that*

$$\frac{1}{\tau} > \gamma > \frac{1-\tau}{\tau}. \tag{34}$$

With competitive pricing vis-a-vis the global investor, the market-clearing interest rate on the traded good bond traded in economy i is defined as:

$$\begin{aligned}\tilde{r}^i_{syn} =& \delta + \gamma\tau((1-Q^i)\overline{\Delta d_T} + \tilde{r}^i_{syn}Q^i) + \gamma(1-\tau)\overline{\Delta d_N} \\ &- \gamma\tau(\frac{\gamma\tau}{2} + (1-\tau))(1-Q^i)^2\sigma_T^2 + \gamma(1-\tau)^2(1-\frac{\gamma}{2})\sigma_N^2.\end{aligned}$$

Taking the derivative w.r.t. to foreign ownership Q^i gives

$$\frac{\partial\, \tilde{r}^i_{syn}}{\partial\, Q^i} = \frac{\gamma\tau}{1-\gamma\tau Q^i}\left(-(\overline{\Delta d_T} - \tilde{r}^i_{syn}) + (\gamma\tau + 2(1-\tau))(1-Q^i)\sigma_T^2\right). \tag{35}$$

Under condition 2b and the assumption that foreign ownership Q^i is maximized at 1, the left term will always be positive. The term in brackets will be negative under assumption 2 and keeping in mind the result that the synthetic rate will always be below the world interest rate for any Q^i, as discussed in the appendix. In combination, this states that the synthetic interest rate goes down as foreign ownership increases. Since the global interest rate r^* is exogenous, and the foreign ownership rate Q^* is determined by the agency problem, this means that the price that the global investor pays for a share of the tree needs to fall in terms of the global bond.

Taking into account these price effects, I can now revist the original set of asset pricing results under aggregate market clearing with global and local investors. First, I define the gap between the world interest rate r^* and the local market-clearing rate $\tilde{r}^i_{syn}$ as

$$l^i = r^* - \tilde{r}^i_{syn}. \tag{36}$$

Using this substitution, I can write the difference in returns on the standard risk-free bond (not the synthetic, traded-good only one) between countries h and f as the standard expression from above, plus an additional term comprised of the gap l^i:

$$
\begin{aligned}
log\,\mathbb{E}(\tilde{R}^h_P) - log\,\mathbb{E}(\tilde{R}^f_P) =& \gamma\tau\left[\frac{\overline{\Delta d_T} - r^*}{\sigma^2_T} - \gamma\tau\left(1 - \frac{Q^f + Q^h}{2}\right)\right]\sigma^2_T(Q^f - Q^h) \\
&+ \gamma\tau(l^f Q^f - l^h Q^h).
\end{aligned}, \tag{37}
$$

where the second row captures the return difference between the countries that is due to the different prices paid by the global investor for a local share. However, it is straight-forward to show that l^i is increasing in Q^i, so that the new term will have the same sign as the original return difference captured by the first term. As a result, the original results are amplified by aggregate market-clearing. When the global investor pays competitive prices for the domestic tree shares, variation in foreign ownership leads to even sharper differences in asset returns across countries. The same result holds for ex-ante interest rate differentials:

$$
\begin{aligned}
\tilde{r}^h - \tilde{r}^f =& \left[\frac{\overline{\Delta d_T} - r^*}{\sigma^2_T} - \left(\frac{(\gamma\tau)^2 + (1-\tau)^2}{\gamma\tau - (1-\tau)}\right)\left(1 - \frac{Q^f + Q^h}{2}\right)\right](\gamma\tau - (1-\tau))\,\sigma^2_T(Q^f - Q^h) \\
&+ (\gamma\tau - (1-\tau))(l^f Q^f - l^h Q^h),
\end{aligned} \tag{38}
$$

where the new term in the second row again takes the same sign as the first, original expression, given condition 2 and the logic described above. Interestingly, relative stock returns are unaffected by allowing for aggregate market clearing. In conclusion, under a small further restriction of the model paramter space, the model results are robust, and even amplified, in a setting in which the global investor pays competitive prices for the local asset and asset markets clear in aggregate.

C Empirical Results and Data

C.1 Country list

Australia, Brazil, Canada, Chile, China, Hungary, India, Indonesia, Israel, Japan, Korea, Malaysia, Mexico, New Zealand, Norway, Philippines, Poland, Russia, South Africa, Sweden, Switzerland, Taiwan, Thailand, Turkey, United Kingdom

Table 2-A1: Data Set

Notes: The sample consists of quarterly data for major advanced and emerging economies with their own currency from 2001 to 2017, excluding the US and the Euro area. Countries drop out of the sample when the currency is considered to be pegged against the USD (see text). Portfolio liabilities/GDP gives the total size of gross portfolio liabilities to foreigners as a precentage of GDP from the IMF CPIS database. Bond return describes the realized return 3-month return on the local currency forward relative to the USD. Forward premium measures the distance between 3-month forward and the contemporaneous exchange rate against the USD. Nominal exchange rate volatility is the monthly standard deviation in the nominal exchange rate against the USD over a rolling 12-month window. Non-traded (traded) sector stock returns are the quarterly USD returns on weighted portfolios of the local MSCI healthcare and financials (industrials and materials) indices. GDP share captures the size of domestic GDP in USD relative to World USD GDP. Share of external debt liabilities issued in USD comes from Benetrix, Lane and Shambaugh (2015), the Import Ratio, measuring the ratio of net imports of complex goods and net exports of basic goods to total trade, is from Ready, Roussanov and Ward (2015). Net International Investment Positions and gross asset and liability positions are sourced from the IMF's IFS database. Gross portfolio inflows are total flows scaled by GDP, gross equity inflows are scaled by domestic stock market capitalization. MSCI country index changes are monthly changes in MSCI index market capitalization less change in the total return index. MSCI investable share is the ratio of the country's MSCI index market capitalization to total domestic stock market capitalization. Ownership concentration is the average percentage of common shares not owned by the top three shareholders in the ten largest non-financial privately-owned domestic firms, from La Porta et al. (1999). Judiciary Efficiency score is the assessment of the legal environment for foreign firms, produced by rating agency ICR, averave of 1980-1983.

Descriptive Statistics

	(1) *Obs.*	(2) *Mean*	(3) *Std.Dev.*	(4) *Min*	(5) *Max*	(6) *P10*	(7) *P90*
Portfolio Liabilites/GDP	1336	39.89	33.20	3.03	158.42	11.31	92.00
Bond return (%, USD, QoQ)	1336	0.68	6.03	-38.71	29.95	-6.51	7.31
Forward Premium (%, QoQ)	1336	0.81	1.35	-2.86	12.94	-0.31	2.24
Nominal Exchange Rate Growth to USD (%, QoQ)	1336	-0.13	5.96	-40.86	20.73	-7.11	6.61
Nominal Exchange Rate Volatility (1-year window, monthly)	1308	0.03	0.02	0.00	0.11	0.01	0.05
Non-traded Sector Stock Return (%, QoQ, USD)	1312	1.61	15.68	-82.11	66.00	-16.23	19.09
Traded Sector Stock Return (%, QoQ, USD)	1267	1.40	16.51	-76.08	62.97	-18.46	19.78
Non-traded vs. Traded Sector Stock Return Differential (%, QoQ, USD)	1244	0.10	11.45	-61.22	62.07	-13.15	12.71
GDP share (%)	1336	1.74	2.36	0.16	15.11	0.24	3.69
Share of External Liabilities issued in USD (%)	944	0.26	0.11	0.03	0.57	0.12	0.39
Import Ratio	726	7.34	32.66	-59.63	73.05	-35.23	60.90
Net International Investment Position/GDP	935	-12.41	54.09	-124.50	195.60	-66.81	63.75
Foreign Assets/GDP (IIP)	935	156.02	170.95	17.72	738.35	25.86	474.04
Foreign Portfolio Assets/GDP (IIP)	935	43.63	57.69	0.04	286.80	0.95	120.92
Foreign Liabilities/GDP (IIP)	935	168.43	146.86	30.17	754.92	54.03	400.18
Foreign Portfolio Liabilities/GDP (IIP)	935	55.31	42.40	3.04	182.96	14.21	126.99
Gross Portfolio Inflows/GDP	1300	0.64	1.29	-6.42	7.60	-0.52	2.09
Gross Equity Inflows/Stock Market Capitalization	1305	0.17	0.80	-11.02	4.63	-0.51	0.90
MSCI Country Index Changes (% of Market Capitalization, QoQ)	1336	0.60	4.33	-56.97	27.35	-1.15	3.74
MSCI Investable Share of Domestic Stock Market (Ratio)	1336	0.39	0.19	0.05	1.03	0.18	0.67
Ownership Concentration*	1151	0.43	0.14	0.18	0.64	0.19	0.59
Judiciary Efficiency Score*	1151	7.46	2.56	2.50	10.00	3.25	10.00

* time-invariant

Table 2-A2: Real Interest Rate Differentials (Forward Premia)

Notes: Pooled OLS regressions with robust standard errors in parantheses, clustered by country. Dependent variable is the difference between current spot and the 12-month forward point of domestic country's currency against the USD, less the realized domestic 12-month forward yoy CPI inflation rate. The sample consists of 26 major advanced and emerging economies with their own currency. I exclude countries with pegged nominal exchange rates to the USD and the US (as the base country) and the Euro area because CPIS does not provide a consolidated account. Portfolio liabilities measures total debt and equity security liabilites to foreigners, scaled by GDP, as captured on a claims-implied basis in the IMF CPIS report at the end of the year, and updated quarterly with flow data from the IMF's BPM6 accounts. GDP share captures the share of global GDP (USD) accounted for by the respective country. FX volatility is computed as the standard deviation in the monthly change in the nominal exchange rate against the USD over a rolling 1-year window. NIIP/GDP is the net international investment positon relative to GDP from the IMF's IFS database.

	(1)	*(2)*	*(3)*	*(4)*	*(5)*
	Real Forward Premium (12-month forward vs. current spot less realized 1-year forward CPI inflation. %)				
Portfolio Liabilities/GDP	**-0.023*****	**-0.022*****	**-0.022*****	**-0.025*****	**-0.023*****
	(0.004)	(0.004)	(0.004)	(0.005)	(0.004)
GDP Share		**-0.027**			**0.100**
(Hassan, 2013)		(0.072)			(0.063)
FX Volatility (1Y trailing)			**62.271*****		**54.110*****
			(12.994)		(12.465)
NIIP/GDP				**-0.005**	**-0.002**
(Della Corte et al. 2016)				(0.004)	(0.003)
Constant	**5.408*****	**5.430*****	**3.181****	**3.828*****	**2.176***
	(1.582)	(1.597)	(1.176)	(1.164)	(1.187)
N	1040	1040	1020	707	698
R-squared	0.205	0.206	0.293	0.215	0.285
Time fixed effects	*yes*	*yes*	*yes*	*yes*	*yes*

Robust country-clustered SEs in parantheses

** p<0.1 ** p<0.05 *** p<0.01*

Table 2-A3: Equity Index Returns

Notes: Pooled OLS regressions with robust standard errors in parantheses, clustered by country. Dependent variable is the quarterly log return on each country's MSCI index in USD. The sample consists of 26 major advanced and emerging economies with their own currency. I exclude countries with pegged nominal exchange rates to the USD and the US (as the base country) and the Euro area because CPIS does not provide a consolidated account. Equity liabilities to market capitalization measures total equity security liabilites to foreigners, as captured on a claims-implied basis in the IMF CPIS report at the end of the year, scaled by total country stock market capitalization as provided by Haver Analytics. GDP share captures the share of global GDP (USD) accounted for by the respective country. FX volatility is computed as the standard deviation in the monthly change in the nominal exchange rate against the USD over a rolling 1-year window. NIIP/GDP is the net international investment positon relative to GDP from the IMF's IFS database.

	(1)	*(2)*	*(3)*	*(4)*	*(5)*
	Excess Equity Return on Non-tradables vs. Tradables Equity Return (QoQ, USD, annl. %)				
Portfolio Liabilities/GDP	**-0.080*****	**-0.080*****	**-0.078*****	**-0.071*****	**-0.060*****
	(0.016)	(0.016)	(0.018)	(0.017)	(0.017)
GDP Share		**-0.037**			**0.232**
(Hassan, 2013)		(0.403)			(0.349)
FX Volatility (1Y trailing)			**98.616**		**146.179**
			(121.044)		(115.457)
NIIP/GDP				**0.008**	**0.009**
(Della Corte et al. 2016)				(0.018)	(0.018)
Constant	**-31.089***	**-31.023***	**-34.555***	**-27.779**	**-32.495**
	(17.366)	(17.462)	(19.580)	(28.408)	(29.277)
N	1355	1355	1328	949	932
R-squared	0.242	0.242	0.246	0.280	0.285
Time fixed effects	*yes*	*yes*	*yes*	*yes*	*yes*

Robust country-clustered SEs in parantheses

** p<0.1 ** p<0.05 *** p<0.01*

Table 2-A4: Instrumental variable regressions with control variables

Notes: Pooled OLS regressions with robust standard errors in parantheses, clustered by country. The dependent variables are quarterly USD returns on 3-month currency forwards (1), the MSCI country index (3), and the relative return on equities in the non-traded sector less the returns on the traded sector (4), while column (2) uses the forward premium implied by 3-month currency forwards against the USD. The sample consists of 26 major advanced and emerging economies with their own currency. I exclude countries with pegged nominal exchange rates to the USD and the US (as the base country) and the Euro area because CPIS does not provide a consolidated account. Portfolio liabilities to GDP are instrumented by the investable share (see text for a detailed description). GDP share captures the share of global GDP (USD) accounted for by the respective country. FX volatility is computed as the standard deviation in the monthly change in the nominal exchange rate against the USD over a rolling 1-year window. NIIP/GDP is the net international investment positon relative to GDP from the IMF's IFS database. Time-fixed effects are partialed out, using the Stata "partial" command.

	(1)	*(2)*	*(3)*	*(4)*
	FX	*Forward Premium (3m)*	*Equity Return (USD)*	*Non-traded Sector Stock*
Portfolio Liabilities/GDP	**-0.065*****	**-0.056*****	**-0.112***	**-0.101*****
IV: Investable Share	(0.022)	(0.018)	(0.058)	(0.030)
GDP Share	**0.191**	**0.216**	**0.279**	**0.265**
(Hassan, 2013)	(0.253)	(0.176)	(0.333)	(0.324)
FX Volatility (1Y trailing)	**163.0*****	**144.8*****	**208.4*****	**164.1***
	(43.848)	(31.638)	(78.022)	(92.240)
NIIP/GDP	**0.013**	**-0.007**	**0.054***	**0.009**
(Della Corte et al. 2016)	(0.012)	(0.006)	(0.029)	(0.023)
N	965	965	885	892
R-squared	0.010	0.417	-0.001	0.005
Time fixed effects	*yes*	*yes*	*yes*	*yes*

Robust country-clustered SEs in parantheses

** p<0.1 ** p<0.05 *** p<0.01*

CHAPTER THREE

On the Edge of Doom:

A Model of Bank Recapitalization with Sovereign Default *

Julian Richers †

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Abstract

What is the best policy response to a financial crisis? At least ex post, theory and practice suggest to rebuild intermediaries' balance sheets, generally with public funds. But what if the government faces a resource constraint herself? This paper addresses the optimal structure of bank recapitalization policy when sovereign debt is risky. I propose a model that combines a classic sovereign default model with private sector financial frictions, which generate fully endogenous and time-varying default costs. When the sovereign lacks commitment, I find that the impact of bank recapitalization on sovereign default risk follows a Laffer curve: Public capital infusions can decrease sovereign spreads when domestic banks are weak, even when transfers are fully financed by external borrowing. At the same time, if transfers are excessively large, recapitalization increases sovereign credit risk. Government bond holdings of domestic banks amplify the mechanism and can generate virtuous and vicious ("doom loop") cycles. This mechanism has implications for macroprudential regulation, optimal bank funding structure, and the workings of a banking union. Private risk sharing mechanisms look like particularly promising tools in order to mitigate sovereign default risk, an insight I discuss in light of Euro area policy reform.

1 Introduction

The European debt crisis and its long-lived reverberations has thrown a spotlight on the deep but little-understood connection between banking and sovereign debt crises. As highlighted in Reinhardt and Rogoff (2008) and in Laeven and Valencia (2012), banking crises have often served as a leading indicator for sovereign crises. In the most recent global financial crisis and its European aftermath, this dynamic has again appeared in highly dramatic ways when governments attempted to shore up their banks with public funds: Coined the "doom loop," deterioration in financial sector stability had detrimental effects on sovereign risk, and vice versa.

Since then, research has begun to explore the interlinkages between sovereign default risk and banking system stability. In particular, one can identify two broad strings in the recent literature: First, works such as Acharya et al. (2014) and Farhi and Tirole (2016) have studied the migration of credit risk in the private sector to public balance sheets. In these models, the sovereign funds a bank recapitalization measure with more foreign debt, which improves bank balance sheet health at the expense of raising the possibility of sovereign default. These papers make important points about risk transmission and regulation but deal rather sparsely with the sovereign's default incentives, simply assuming an exogenously given, time-invariant default penalty.

In contrast, in order to improve on the assumption of a fixed, exogenously given cost of default, other papers have employed insights from the crisis to microfound the sovereign's decision problem. In work such as Genneaioli et al. (2014) or Perez (2016), the sovereign can credibly promise to repay even high levels of outstanding debt because a default would damage the domestic financial institutions, which also hold government bonds on their balance sheets. Default costs become endogenous and high enough to resolve persistent puzzles in the literature. However, in turn these papers struggle with matching the empirical evidence on the co-movement between sovereign and banking system risk. Since sovereign default is costly because of its adverse effects on bank net worth, default costs are highest when banks are already weak. Hence, in these models, the government's incentive to repay is inversely related to the health of the banking system. The sovereign will be most likely to repay when banks are weak, and to default when banks are strong - exactly the opposite of the dynamics in the first set of papers, as well as the pattern in the data.

With this background in mind, this paper proposes a model of sovereign default that can reproduce the empirical co-movement between public and private (banking) sector credit risk. Despite generating endogenous default costs, bank recapitalization or discriminative default are nested and do not invalidate the mechanism. Indeed, the model can serve to shed light on the optimal structure of bank recapitalization when the sovereign's default incentives are taken into account. Extensions of the model show the pathways for mutual contagion between sovereign and banks through two different but connected sources of credit risk in each sector, which can offer further insight into optimal regulatory policy. In particular, it highlights the benefits to be had from incorporating private market risk sharing mechanisms.

At its base, the model builds on the external financial accelerator in Gertler, Gilchrist and Natalucci (2007) and combines it with a classic default model of a sovereign without commitment. I then add two assumptions that make the model relevant to the question at hand: First, I allow the sovereign to borrow funds and transfer them to the private intermediary (recapitalization). Second, the intermediary's funding options are determined by the sovereign's standing in international credit markets.

In the model, banks are the sole owners of capital in the economy, while households provide fixed labor supply. Banks have the choice between raising funds from domestic households, which only require a fixed rate of return independent of the banks' net worth (akin to deposit insurance), or from international lenders. Since borrowing internationally is risky because of observational frictions, external borrowing costs are determined by the banks leverage. If international borrowing costs are lower than domestic rates, the country will be a net debtor and benefit from capital inflows from abroad.

At the same time, the sovereign borrows from international lenders to fund required government spending and (potentially) transfers to the banks. Importantly, since the sovereign's default decision determines the private sector's financing options, this generates an expanded Eaton Gersovitz (1981) -type punishment for sovereign default: Not only is the sovereign excluded from international financing markets if she fails to repay, but so is the local financial system. Domestic banks then have to rely solely on domestic financing.

This generates fully endogenous default costs for the sovereign, which vary with the state of the financial system. If domestic banks are well capitalized, then international financing will be cheap, and hence total capital (and total income) in the next period will be high if international financing access is preserved. If future income with international financing is sufficiently above total future income under domestic financing, the potential gain incentivizes the sovereign to repay her debts.

However, if the financial system is weak, international borrowing costs are high, and the value of the foreign financing option will be low. Hence, the sovereign may choose to default even on small amounts of outstanding debt. Ex ante, international lenders can anticipate the risk of sovereign default based on economic risk as well as the initial state of bank balance sheets, and price bonds accordingly.

This mechanism highlights the potential benefits from recapitalization: Under some conditions, the model shows that transferring funds from the sovereign to the banking system increases the expected benefit from sovereign debt repayment. Hence, the sovereign can credibly lower her own risk of default (and increase welfare) even if recapitalization is funded with additional foreign borrowing. In this context, increasing banking system net worth can play the role of a commitment device.

However, bank recapitalization is a delicate endeavor. If the government already faces substantial outstanding debts, or if the recapitalization is too large, the increase in the required repayment can swamp the benefits from higher bank net worth. In combination, I show that bank recapitalization follows a Laffer curve when taking sovereign default risk into account. When the government already faces a large debt burden and benefits from international financial integration are low, large-scale bank recapitalization can actually be destabilizing. At the same time, the model demonstrates how bank recapitalization can serve to reduce sovereign risk outright, even as the amount of external sovereign debt increases.

In its most basic form, the model highlights the sensitivity of public creditworthiness to the state of the domestic banking system. But the model can be easily extended to incorporate a parallel sensitivity of bank balance sheets to sovereign risk, such as by allowing banks to hold domestic sovereign bonds. This generates a two-way risk transmission mechanism between public and private credit risk, and allows for virtuous and vicious ("doom") feedback loops: Lower (higher) sovereign credit risk lead to strengthened (weakened) bank balance sheets through a revaluation of domestic bond holdings, which further improves (worsenes) the sovereign's future repayment incentives. Similarly, stronger (weaker) bank balance sheets decrease (increase) sovereign credit risk by raising relative default costs, which further strengthens (weakens) bank net worth through their bond holdings.

As alluded to above, this paper builds on two different strands of the literature. First, the model suggests a new angle on default incentives and disincentives for the government of a net debtor economy. In thinking about the costs of sovereign default, Eaton and Gersovitz (1981) first proposed that the main cost of default to the sovereign comes from losing access to international capital markets. However, it is difficult to generate sufficiently high costs to the government through this channel to make default infrequent enough to match the data. In my model, by tying the domestic financial system's financing options to the government's default decision, I can generate higher endogenous and time-varying default costs, since market exclusion extends to the financial system and is hence more consequential. As a result, default is more likely when the financial system is weak, which makes the model consistent with the observation in Reinhart and Rogoff (2011), who show that sovereign default events are often preceded by financial crises.

There has been some work on the interaction of sovereign default and the financial system, such as Genneaioli et al. (2014), Perez (2015), or Balloch (2016). In contrast to this paper, their emphasis is primarily on the "plumbing" of the domestic financial system. Sovereign default is costly because it destroys the safe asset that is used for intermediation purposes. These models broadly disregard international borrowing by the private sector and do not allow for discriminative default and government-led recapitalization (at least not if they fully offset the damage to domestic bond holders). Balke (2016), while predominantly interested in the labor market impact of sovereign default, relies on a similar mechanism.

In comparison, this paper directly models external borrowing by the private sector and relates it to sovereign default incentives. This step allows me to avoid a common, unintuitive feature of the models discussed above: If sovereign default is costly predominantly because of its effect on (domestic) intermediation, the government is more likely to default when bank balance sheets are strong. The opposite is true in the model at hand, which opens up the possibility to allow for recapitalization explicitly, and to study the synergies between private and public balance sheets.[1]

Furthermore, because of the soft barrier between public and private balance sheets, there is now room to think about contagion from private to public credit risk. A comparable dynamic appears in Acharya et al. (2014) where financial services are treated as a complimentary intermediary good. My work here allows for a more direct model of relative funding costs and hence allows for a more explicit

[1] In this way, this paper has a different target than Du and Schreger (2017), who also build a model with both private and public sector borrowing. In their model, foreign-currency denominated private sector debt increases the risk of a sovereign default on local-currency denominated debt because the alternative, eroding the real debt value through higher inflation, would increase debt overhang in the private sector. Apart from the topic of currency denomination, not accounted for in the purely real model presented here, my work differs with regard to two key assumptions: First, Du and Schreger (2017) assumes that private access to international credit market remains unaffected by sovereign default events, and that the default decision is costly because of an exogenous, fixed reduction in productivity.

trade-off between private and public credit spreads. By modeling the two different sources of credit risk, I am able to determine an optimal policy for recapitalization in the presence of endogenous sovereign default risk.

The second strand of the literature that this paper relates to is the study of bank recapitalization and bailouts. Here, a large body of work has focused on the moral hazard cost of bank bailouts, and how to structure resource transfers most efficiently in the face of agency frictions. One timely example of this work is Philippon and Schnabl (2013). Other research has focused on exploring the ways bank bailouts impact the financial system, for example as liquidity provision in Gorton and Huang (2004), all while taking the source of recapitalization funds as exogenous. Panageas (2010) discusses the optimal taxation approach to finance bank bailouts, however without including a feedback effect from banks to sovereign. Stavrakeva (2013) examines how fiscal capacity constraints affect the optimal level of risk-taking and regulation in domestic banking systems.

Farhi and Tirole (2016) provide another recent and important addition to the literature. Their paper is predominantly concerned with the banking system's incentives when bailouts are possible, as well as with national and supra-national supervision. Their model features a strong feedback effect between sovereign and bank balance sheets but is less directly concerned with the optimal structure of bank recapitalizations ex post and their effect on the sovereign's default incentives, the main focus of my work here.

Finally, Acharya et al. (2014), as discussed above, is closest to the discussion at hand since it explicitly models the feedback loop between sovereign and banks. There are some parallels to this in Leonello (2018), which focuses on the role of government guarantees for the banking sector. While guarantees work differently from explicit recapitalizations, and the model is based on roll-over risk, she also highlights some of the feedback effects I show in this paper.

The remainder of the paper is organized as follows: Section 2 describes the model and chapter 3 shows the main results. Chapter 4 extends the model to include the sovereign-banking nexus and explores the impact of alternative bank funding structures. Chapter 5 highlights the model's policy implications, and chapter 6 concludes.

2 Model

The three-period model features households, banks, firms, foreign investors and the government. Households provide a fixed amount of labor and solve a consumption-savings problem. Banks intermediate funds, either from domestic deposits or from international capital markets, to the firm, which hires inputs to production in spot markets and produces the single consumption good. Importantly, while bank financing costs from domestic deposits are determined solely by the household's time preferences, the cost of foreign borrowing depends on bank leverage. Finally, the government, which seeks to maximize household welfare, issues one-period bonds to international lenders in order to fund a fixed amount of government spending. It can issue additional debt to finance bank recapitalization, which lowers bank leverage, but may increase the risk of sovereign default, and hence the required interest rate on government bonds. Importantly, recapitalization is only possible at t=0, and risk only enters the model through uncertainty about production technology in period 1. Once capital and labor returns are realized, banks repay their creditors and the government subsequently decides whether to default or not, based on the possible payoff outcomes in the last period.

2.1 Setup

I now describe the time path of the model and the individual agents' optimization problems:

- At t=0, the government issues debt to finance a required amount of government spending. It also observes the current level of net worth in the banking system and can inject additional funds (recapitalization). Both types of spending are funded by issuing one-period bonds to foreign investors. Foreign investors calculate the required risk spread on government bonds based on expectations about future default. Banks attract domestic deposits or borrow from foreign investors, and invest in capital for t=1, based on their expectation of future productivity A_1. Banks' foreign borrowing costs are dependent on the bank's external financing premium (leverage).

- At t=1, the productivity state is revealed and the firm hires capital and labor in the spot market to produce the single consumption good. Banks receive the market clearing rental rate on capital and repay their depositors or foreign lenders. Households receive their wage income, consume and/or save. The government decides whether to repay foreign borrowers, in which case households have to pay a lump-sum tax, or to default. If bondholders are paid back, banks can again borrow from abroad and invest in capital, this time while knowing returns at t=2 with certainty. In the case of default, banks lose access to foreign borrowing and can only access domestic deposits at a fixed interest rate.

- At t=2, the firm again hires capital and labor and produces according to current productivity. Banks receive capital income and pay back their borrowed funds or deposits with interest. Total resulting net worth is then transferred to the households. Households in turn consume their labor income, possible savings with interest, and the final net worth of the banks.

2.2 Households

Households are assumed to be risk-neutral consumers, discount future periods at the rate β, and inelastically provide a fixed amount of labor. For the three periods, households choose consumption to maximize:

$$\mathbb{E}[c_1 + \beta c_2], \tag{1}$$

subject to the budget constraints:

$$c_1 + d_1 = w_1 - b^* \cdot \mathbb{I}_{\{D=0\}}, \tag{2}$$

$$c_2 = R_2 d_1 + w_2 + n_2, \tag{3}$$

Households earn wages w_1 and w_2, receive interest rate R_2 on deposits d_1, if they choose to save, and collect the leftover equity in the banks, n_2 in period two. In the no-default case, i.e. $D = 0$, the households are taxed lump-sum for the required repayment of outstanding foreign borrowing b^*.

2.3 Government

The government seeks to optimize household welfare in the economy, hence its optimal decision program has to satisfy:

$$V_0 = \max_{b^*} \mathbb{E}[\max_{D \epsilon \{0,1\}} \{V_1, V_1^d\}], \tag{4}$$

where b^* denotes the amount of sovereign debt issued to international investors from t=0 to t=1, and D captures the binary default decision in period t=1. The government only issues short-term debt at t=0, and makes the decision to repay at t=1. If the government does not default in period 1, then lump-sum taxes $T_1 = b^*$ are raised from households to pay for the maturing debt. Hence, the continuation values in period 1 are:

$$V_1(b^*, A_1) = c_1 + \beta c_2,$$
$$V_1^d(b^*, A_1) = c_1^d + \beta c_2^d,$$

where c_t and c_t^d denote consumption in the non-default and the default state respectively. $A_1 \epsilon [\underline{A}, \bar{A}]$ denotes the realization of the stochastic productivity level in the economy.

Since productivity is the only source of uncertainty, I can define a default and a repayment set given the outstanding levels of short-term debt, b^*, which make either decision optimal for the government:

$$D(b^*) = \{A_1 \epsilon A : V_1 < V_1^d\},$$
$$R(b^*) = \{A_1 \epsilon A : V_1 \geq V_1^d\}.$$

Short-term debt is issued at t=0 in order to finance required government spending g and potentially also a recapitalization of the banking system, denoted rc. This gives a set of budget constraints for the government:

$$qb^* = \frac{1}{(1-\tau)} rc + g, \tag{5}$$

$$(b^* - T_1) \cdot \mathbb{I}_{D=0} = 0, \tag{6}$$

where T_1 denotes tax revenue, and q denotes the price of the bond when issued. τ describes the efficiency loss inherent in the bank recapitalization, i.e. the amount lost per unit of net worth transfered because of moral hazard or other inefficiencies inherent in the recapitalization process. [2]

The government also provides an insurance scheme for domestic depositors. But since the required funds would similarly be raised by taxing households lump-sum, this has no effect on outcomes in the model and I hence abstract from modeling it explicitly.

[2] Another reasonable assumption here would be to include a fixed cost on initiation of the capital injection. This would serve to make the model more realistic by creating larger "inaction zones" for the government (since bank recapitalization is a rare event) but since the model is primarily concerned with what happens around bank recapitalization, I will abstract from this here.

2.4 Foreign Lenders

Foreign lenders are assumed to be risk neutral and make similar consumption-savings decisions as domestic households, however with a foreign discount factor β^*. This gives a required rate of return in the global savings markets:

$$R^w = \frac{1}{\beta^*}. \tag{7}$$

I assume that global savings are provided perfectly elastically at this rate of return, and not at all at any lower rate. As a result of risk neutrality, the expected return on the sovereign bond thus needs to match the required rate of return in the global market. If the probability of sovereign default is non-zero, then the sovereign bond needs to be priced such that:

$$\frac{1}{q} = \frac{1}{1-p(b^*)} R^w, \tag{8}$$

where $p(b^*)$ denotes the probability of default on the government bond, given the required repayment amount b^* (no partial default option is assumed). As a result, the bond price q takes values on the interval $q \epsilon [0, \frac{1}{\beta^*}]$.

2.5 Firms

Firms competitively produce the single consumption good in the economy by hiring capital from banks and labor from households in spot markets in each period, after the state of technology A is revealed. Firms optimize a simple Cobb-Douglas production function:

$$\max_{k,l} A_t k_t^{\alpha} l_t^{1-\alpha} - r_t^k k_t - w_t l_t \tag{9}$$

This optimization yields the conventional first order conditions for the return on capital and wages.

2.6 Banks

Banks are the sole owners of capital. Banks can lever their net worth n_1 by taking domestic deposits or by borrowing from foreign investors to invest in capital. Banks are risk-neutral and, given a starting position of net worth n_0, seek to maximize the amount of equity left in the last period

$$\mathbb{E}[n_2], \tag{10}$$

subject to the budget constraints:

$$n_0 = \bar{n} + rc \tag{11}$$

$$n_1 = R_1^k k_1 - R_1 d_0 - R_1^* d_0^*, \tag{12}$$

$$n_2 = R_2^k k_2 - R_2 d_1 - R_2^* d_1^*, \tag{13}$$

where R^k denotes the gross return on capital, R the interest rate on domestic deposits, R^* the interest rate on foreign borrowing, and d and d^* domestic deposits and foreign borrowing respectively. Capital fully depreciates each period. As discussed above, $\bar{n}$ is the initial starting equity in the banks, and rc captures the government recapitalization at $t = 0$.

As noted above, the interest costs banks face on the two different funding sources do not need to be the same. The key distinction here is that while domestic deposits are insured, foreign borrowing is risky. Because the government insures deposits for domestic households, the required rate on domestic deposits is time-invariant and pinned down by the household's optimization problem's FOC,

$$R = \frac{1}{\beta}. \tag{14}$$

Since the government does not insure foreign lenders and because of observational frictions, foreign borrowing costs are instead dynamically determined as in GGN, namely as combination of the world interest rate, and a leverage risk premium:

$$R_t^* = \chi[\frac{k_t}{n_{t-1}}]\frac{1}{\beta^*}. \tag{15}$$

χ is the standard expression for the external financing premium in the financial accelerator literature, a strictly increasing convex function of leverage. The premium depends on the amount of total capital held by the bank relative to the strength of its balance sheet. While I refer to the literature for the explicit microfoundations, intuitively one can think of the increasing costs of leverage as the result of costly state verification. When banks have less skin in the game, they may choose to do more opaque investments that require a tighter oversight by international lenders and hence require a higher rate of compensation. This spread is then combined with the required world interest rate, determined by foreign investors in the global savings market.

Since savings supply is perfectly elastic at the prevailing interest rates in the global market as well as by domestic savers (at least up to the limit of all available resources in the domestic economy), it is clear that unless the rates are exactly the same, banks will only use one source of funding. Hence, banks will rely on foreign borrowing rather than domestic deposits if:

$$\frac{1}{\beta} > \chi[\frac{k_t}{n_{t-1}}]\frac{1}{\beta^*}.$$

The main source of welfare losses from sovereign default in this model is domestic banks' loss of access to international funding markets. As a result, for the model to deliver dynamics relevant for the questions at hand, it needs to be the case that the country is a net debtor, i.e. that the condition above holds in period 1.[3]

Note while this needs to hold for n_0 as defined above, which includes the recapitalization, it does not necessarily need to hold in absence of it, i.e. for $n_0 = \bar{n}$. It is possible for banks to face prohibitively high foreign funding costs and hence rely solely on domestic funding if the government decides not to recapitalize the system. In practice, this would mean that in absence of recapitalization, default on any amount of sovereign debt (i.e., any g) is certain, since there is no benefit at all to preserving international financial integration. However, recapitalization can shift the equilibrium outcome from certain to stochastic default under some conditions.

In short, bank recapitalization by the government serves to reduce the external financing premium banks face when capital levels are low. However, since the capital transfer comes with an increase in government debt, this might lead to an increase in sovereign risk. The counteracting trajectories for the two sources of funding spreads suggests an interior solution for an optimal bank recapitalization.

2.7 Equilibrium

In equilibrium, the government maximizes welfare, households and foreign lenders maximize consumption utility, firms maximize profits, and banks maximize expected net worth. Markets for domestic deposits, foreign borrowing, sovereign bonds, labor and capital all clear.

Definition 1 *Equilibrium in the economy is defined as a set of policy functions for consumption* c_1, c_2*, domestic deposits* d_1*, foreign borrowing* d_0^*, d_1^**, government bond issuance* b^**, capital returns*

[3] As a result, households either save domestically or not at all. Under the assumption that the country is a net debtor, $\frac{1}{\beta} \geq \frac{1}{\beta^*}$ and external savings options are not attractive to domestic households.

r_1^k, r_2^k, wages w_1, w_2, repayment sets $R(b^*)$, default sets $D(b^*)$, and bond prices q such that:

1. *The plans for consumption and domestic deposits, c_1, c_2 and d_1, maximize households' expected utility subject to their budget constraint, taking wages, interest rates, government policy, and banks' behavior as given.*

2. *Banks maximize their expected net worth in period 2 by choosing capital, domestic deposits and foreign borrowing subject to budget constraints and financial frictions. Deposit and foreign borrowing markets clear.*

3. *Firms maximize profits by hiring the optimal amount of labor and capital, and labor and capital markets clear.*

4. *Government bond issuance b^*, the repayment and the default sets satisfy the government's optimization problem, taking into account the impact of debt levels on bond prices.*

5. *Bond prices q reflect the government's true default probabilities, and are consistent with the foreign lender's maximization problem.*

Since there is no uncertainty in period t=2, I can solve the model backwards. The lack of uncertainty allows for calculating the continuation values V_1 and V_1^d for a given amount of short-term debt outstanding and realized technology level A_1. This yields a decision rule for when default is optimal. Assuming a probability distribution for A_1 allows to compute the probabilities of default, and then to back out the optimal b^* in period 0, which is equivalent to finding the optimal amount of recapitalization for a given g and $\bar{n}$. I describe the solution in the appendix.

3 Results

This section discusses the model's equilibrium outcomes and what they imply about the relationship between sovereign risk, bank balance sheet health, and recapitalization. There are three main results: First, I show that sovereign default risk is lower when banks are well-capitalized ex ante. Second, as a result, bank recapitalization can serve to decrease sovereign default risk even when transfers are financed through additional external borrowing. Third, however, the model als demonstrates that when recapitalization transfers are excessively large, they become self-defeating and increase default risk. Taken together, the second and third result generate a 'Laffer curve' for bank recapitalization.

Finally, the model can be shown to satisfy the standard criteria of sovereign default models, i.e. it features default in equilibrium, and the sovereign's default incentives are increasing in the amount of external borrowing, all else equal.

In order for the model to generate interesting results, I first have to make a key assumption on the parameterization of the model. Since the model features two different financing sources for the domestic banking system, households need to discount the future more (and hence require a higher risk-free return) than international lenders. This ensures that access to international financial markets is valuable, at least in certain states, despite the external borrowing premium that banks face.

Assumption 1 . *Domestic households are assumed to have a lower discount factor than international lenders:*

$$\beta < \beta^*.$$

I now discuss two basic properties of the model that simplify solving the equilibrium. First, for convenience, I split the no-default condition from above in period 1 value functions for the repayment and the default case[4]:

$$v_1 = w_2(n_1) + R_2^k(n_1) \cdot n_1 - \frac{1}{\beta} b^* \tag{16}$$

$$v_1^d = w_2^d + R_2^{k,d} \cdot n_1, \tag{17}$$

so that v_1 and v_1^d are truncations of the government's respective welfare values V_1 and V_1^d. Wages w and capital returns R^k are dependent on bank net worth n_1 in the repayment outcome, but not in the default state. As these simplified value functions show, period 1 bank net worth has a larger effect on welfare in the repayment state (where wages and capital returns - both per unit and in total - depend on it) than in the default state, at least as long as n_1 lies in a moderate range. This translates into a restriction on the range of possible recapitalization amounts that the model can handle:

Assumption 2 . *The total amount of initial bank recapitalization transfers is bounded above so that*

$$rc < \left(\frac{1}{R_1^k(\bar{n}, \bar{A})} \right) \bar{\bar{n}} - \bar{n},$$

[4]See the solution description in the appendix for more detail.

where $\bar{\bar{n}}$ is such that

$$\frac{\partial\left(w_2(\bar{\bar{n}})\right)}{\partial n}+\frac{\partial\left(R_2^k(\bar{\bar{n}})\bar{\bar{n}}\right)}{\partial n}=\frac{1}{\beta}.$$

In words, the space for possible recapitalization amounts is restricted in a way so that even in the highest technology state $\bar{A}_1$, the net worth accumulated in the banking sector in period 1 does not surpass the upper bound $\bar{\bar{n}}$. The upper bound is defined as the level of net worth at which the marginal increase in total wage income and total capital income for the domestic economy from an additional unit of bank net worth is exactly equal to $\frac{1}{\beta}$, the domestic discount factor. Intuitively, $\bar{\bar{n}}$ marks the socially optimal level of bank net worth in this economy, given household preferences, taking into account labor income externalities and without regard to sovereign default risk.

Lemma 1 . *Under assumption 2, one unit of bank net worth will always be more valuable in the repayment state than under default, i.e.*

$$\frac{\partial v_1}{\partial n_1}>\frac{\partial v_1^d}{\partial n_1}.$$

From above, recall that period 2 capital levels (and hence wages and total capital returns) are increasing concave functions of n_1, hence this is also true for v_1, keeping debt outstanding b^* constant. At the same time, v_1^d is linear in n_1. Under assumption 2, which states that n_1 is bounded above, and by its concavity, v_1 increases faster in n_1 than v_1^d over the defined range. This implies that the two value functions can cross at most once. In practice this means that there exists a unique default threshold $\tilde{n_1}$ at which the sovereign is indifferent between default and repayment, resulting in the second lemma.

Lemma 2 . *If default is optimal for some period 1 bank net worth n_1, then default is also optimal for all $\tilde{n_1}<n_1$, holding debt oustanding b^* constant. Therefore, there exists a threshold $\tilde{n_1}$ below which the government always chooses to default, and above which it always repays.*

Furthermore, n_1 is a function of initial bank net worth, n_0, and the realized productivity state A_1, where A_1 is plucked from a continuous distribution over $[\underline{A},\overline{A}]$:

$$n_1=\alpha\left[A_1-\mathbb{E}(A_1)+\mathbb{E}(A_1)\frac{n_0}{K_1}\right]K_1^{\alpha}, \tag{18}$$

where K_1 is a function of n_0 and ex ante default probability p. Since banks gain more on their investments when productivity outcomes are high, n_1 is increasing in realized productivity A_1, holding $\mathbb{E}(A_1)$ constant. Hence,

$$\frac{\partial n_1}{\partial A_1} > 0 \Rightarrow \frac{\partial v_1}{\partial A_1} > \frac{\partial v_1^d}{\partial A_1},$$

i.e. lemma 1 also applies with respect to technology outcomes. As a result, lemma 2 can be extended to give lemma 3:

Lemma 3 . *If default is optimal for any* $A_1 \in [\underline{A}_1, \bar{A}_1]$*, then there exists* $\tilde{A}_1$ *s.t.* $v_1(\tilde{A}_1) = v_1^d(\tilde{A}_1)$*. Then, by assumption 2,* $v_1(\tilde{A}_1) < v_1^d(\tilde{A}_1)$ *for all* $A_1 < \tilde{A}_1$*, i.e. default is optimal for all productivity realizations below the default threshold* $\tilde{A}_1$*.*

As a result, the set of productivity realizations that trigger a default for a specific amount of sovereign debt outstanding is an interval. The probability of default can then be rewritten as

$$p(b^*, n_0) = \int_{\underline{A}_1}^{\tilde{A}_1} f(A)d(A), \tag{19}$$

where $f(A)$ denotes the pdf of the stochastic productivity level, and $\tilde{A}_1$ is the default threshold for a given n_0 and debt outstanding b^*, as described above.

3.1 Bank net worth

As lemma 2 shows, under reasonable assumptions about bank capitalization, higher ex post (i.e. t=1) net worth makes default less desirable for the sovereign. This suggests that ex ante, default risk should also be lower when banks' initial net worth is high. For this intuition to hold, it needs to be the case that an additional unit of initial net worth does not lead to a decrease in period 1 net worth for any realization of A_1.

This is trivial in good states, where higher net worth can support higher capital levels, and hence higher overall returns for the bank. Things are less obvious when realized productivity comes in below expectations, since banks suffer a loss on their invested capital, which grows with net worth. However, next period's capital choice is a concave function of current period bank net worth, as returns to capital are decreasing in scale, given the fixed labor supply.Hence, leverage per unit of net worth actually decreases as bank equity increases. This means that losses per unit of net worth fall, so that higher initial net worth still leads to higher net worth in the next period relative to lower initial net worth, even in the lowest productivity state $\underline{A}_1$. This logic formally holds for reasonable levels of n_0.

As a result, period 1 net worth n_1 is increasing in initial net worth n_0 for any realization of A_1. Then, lemma 2 applies, yielding proposition 1.

Proposition 1 . *For any fixed amount of required government spending g, default risk* ***decreases*** *with initial bank net worth n_0.*

Why do better-capitalized banks lead to lower sovereign default risk? The answer lies in the role that bank net worth plays in the model. Keeping sovereign default probability fixed for the moment, a higher level of bank capitalization lowers international funding costs for banks and hence increases the amount of capital in the economy in the next period. As the amount of capital in autarky is fixed, this increases the welfare gain in the non-default state relative to the default state. Hence, bank capital takes on the role of a commitment device (which can be actively deployed, as shown in the next section). Well-capitalized banking systems promise higher relative welfare losses from default, and can therefore support higher levels of government borrowing.

This result is fundamental for the model and for motivating bank recapitalization even when the sovereign may already have large borrowing requirements. Importantly, it also sets this paper apart from most other sovereign default models with a financial sector, where the sovereign is actually **more** likely to default when banks have strong balance sheets.

3.2 Debt-funded bank recapitalization

Since stronger bank balance sheets reduce the risk of sovereign default, a logical next step is to think about government-led bank recapitalization. When a shock hits the financial system, can government intervention help in reducing private and public risk? This section explores how - and under what circumstances - recapitalization can reduce sovereign risk, even if it is funded by additional issuance of government debt.

At the beginning of the analysis of bank recapitalization in the model stands the key assumption from above: A unit of bank net worth is more valuable when the government repays its debts than when it defaults. Hence, since stronger balance sheets increase repayment incentives, bank net worth becomes a commitment device for the government, which illuminates the role that bank recapitalization plays in the model. However, when the transfer of resources from sovereign to private sector has to be funded by issuing more debt, this in turn increases the sovereign's incentive to default. Will recapitalization hence be beneficial for sovereign risk or not? As visible in figure 1, the answer is 'it depends.' In fact, the interaction of default and repayment incentives generates a 'Laffer curve' for bank recapitalization, in which debt-financed transfers to the financial system can actually reduce sovereign default risk when banks are weakly capitalized. However, they can also worsen the sovereign risk profile when they become too large (or the financial system is already well-funded).

In order to analyze the counteracting incentives of debt-funded recapitalization, I rewrite the government's truncated value functions from above such that

$$v_1^* = w_2(n_1) + R_2^k(n_1) \cdot n_1, \tag{20}$$

$$v^b = \frac{1}{\beta} b^* = \frac{1}{\beta}\frac{1}{q}\left(g + (\frac{1}{1-\tau})rc\right), \tag{21}$$

$$v_1^d = w_2^d + R_2^{k,d} \cdot n_1, \tag{22}$$

where $w_2(n_1)$ and $R_2^k(n_1)$ denote wages and capital returns in the repayment state, which are concave functions of bank net worth in period 1, n_1. v^b denotes the value of the required debt repayment, made up of required government spending g and recapitalization amount rc, where q denotes the issuance price of the bonds, and τ denotes the efficiency loss incurred in the resource transfer. v_1^d captures the utility in the default case, as above.

From above, since $v_i^* - v^b = v_i$, we know that

$$\frac{\partial v_1^*}{\partial n_0} > \frac{\partial v_1^d}{\partial n_0}.$$

Since $n_0 = \bar{n} + rc$, this implies

$$\frac{\partial v_1^*}{\partial rc} > \frac{\partial v_1^d}{\partial rc} = \frac{1}{\beta}.$$

Further, v_1^* is a concave function of n_0 (and hence rc), since a fixed labor supply generates decreasing returns on capital. As default-state capital levels are fixed, this is not true for v_1^d, which is linearly increasing in n_1. This in turn means that the function $\frac{\partial v_1^*}{\partial rc} - \frac{\partial v_1^d}{\partial rc}$ is decreasing in rc, and concave. As the amount of recapitalization increases bank net worth, each additional unit produces a lower gain over the default scenario, which suggests that recapitalization becomes less useful as a commitment device when banks are already well-capitalized.

Finally, the important addition relative to the earlier section is that now the sovereign also faces a change in its outstanding debt:

$$\frac{\partial v^b}{\partial rc} = \frac{\partial}{\partial rc}\frac{1}{\beta}\left[\frac{1}{q}\left(g + \frac{1}{1-\tau}rc\right)\right]$$

$$= \frac{1}{\beta}\left[\frac{1}{q(1-\tau)} + (\frac{\partial q}{\partial rc})^{-1}\left(g + \frac{1}{1-\tau}rc\right)\right].$$

The debt burden of the sovereign responds to recapitalization in two ways. First, debt outstanding increases at the rate $\frac{1}{q(1-\tau)} > 1$ per unit of rc, where q is the bond issuance price given current default risk. Secondly, if the recapitalization leads to a change in default risk, and hence in bond price q, this leads to a revaluation of total government debt, i.e. funds raised. As a result, when recapitalization leads to lower default risk, the face value of debt outstanding, b^* can fall even as total funds raised in period 0, given by $g + \frac{1}{1-\tau}rc$, actually increase.

However, as long as there are no discontinuities in the distribution of productivity A_1 (such as in a discrete distribution), small changes in rc should not lead to large changes in default risk, and therefore the first term should dominate the effect. This true at any point outside of the transition between certain and stochastic default that, depending on the assumed distribution of A can be quite abrupt.

Taking it all together, $v_1^* - v_1^d - v^b$ is a concave function of rc. For changes in rc small enough, i.e. such that overall changes the ex ante default probability are small enough so that the revaluation effects of the total debt stock are negligible,

$$\frac{\partial v_1^*}{\partial rc} > \frac{\partial v_1^d}{\partial rc} + \frac{\partial v^b}{\partial rc} \approx \frac{1}{\beta} + \frac{1}{\beta}\frac{1}{q(1-\tau)}.$$

But as rc increases and the incremental returns to capital in the repayment state decrease, this relationship will switch such that

$$\frac{\partial v_1^*}{\partial rc} < \frac{\partial v_1^d}{\partial rc} + \frac{\partial v^b}{\partial rc},$$

as v_1^* increases less rapidly than the linear increases in v_1^d and v^b combined. Figure 2 illustrates the behavior of the three functions graphically. This describes the origins of the recapitalization

Laffer curve.

Lastly, depending on the probability distribution of A_1 and the amount of government debt outstanding, g, the effects of recapitalization on the value of the total debt outstanding can be large. This is especially true when a small amount of recapitalization shifts the equilibrium from certain to stochastic default. However, since the revaluation effect follows the same direction as the underlying welfare gain, this only serves to amplify the dynamics highlighted in the simplified value functions above: If an increase in the amount of recapitalization increases difference between utility in the repayment versus the default state, this leads to a decrease in the productivity threshold for default, $\tilde{A}_1$. As discussed above, this reduces the probability of default and hence lowers the required repayment b^* in period 1, which further improves the attractiveness of the repayment state relative to the default state. The opposite is true when a change in the recapitalization worsens the benefit in the repayment state relative to default.

Hence, even when the distribution of A_1 is prone to large or even discrete shifts, which could generate large revaluation effects for small changes in recapitalization, this only provides amplifying, not countervailing force on the valuation of the two possible outcomes.

4 Extensions

4.1 Government bond holdings

In the discussion of the links between sovereign default and the domestic financial system, an often-discussed component is the amount of sovereign debt that is domestically held. In fact, in other models that have used the financial system to generate endogenous costs of sovereign default, domestic bond holdings are essential. Default in those models only affects the banking system through their holdings of sovereign bonds, which lead to balance sheet losses as well as a reduction in the availability of the main instrument of financial intermediation.

In the European crisis, high concentration of domestic bonds on bank balance sheets was considered one of the main reasons for sovereign risk contagion. However, as I show in the following, integrating domestic bond holdings into the model provides some additional complexity, but mainly strengthens the underlying dynamics.

First, I assume that banks start off with an exogenously determined stock of long-term domestic government bonds, denoted b. I then assume that these bonds can be pledged in international borrowing (akin to a repo transaction) and hence function just like bank net worth - however with the slight modification that domestic bond holdings are 'mark-to-market,' i.e. that their pledge value will fluctuate with the price q of bonds issued to foreigners. This means that for a given n_0 and b, banks are facing foreign borrowing costs such that:

$$R_1^* = \chi[\frac{k_1}{n_0 + qb}]\frac{1}{\beta^*}. \tag{23}$$

This makes government default appear indiscriminate, i.e. the government cannot selectively default. This distinction is not particularly meaningful however, since in the default case, capital is funded exclusively through domestic deposits. Bank net worth is therefore irrelevant for future bank funding costs. Since bonds are also repaid by taxing domestic households (the final recipient of terminal bank net worth), welfare is unchanged if discriminate default is assumed. If the government does not default, bonds are repaid through the same lump-sum taxes that fund the repayment of foreign bonds.

The function above already shows the amplification that domestic bond holdings provide in the transmission of sovereign risk. Increasing sovereign default probability from lower bank net worth is further amplified by the commensurate decline in the mark-to-market value of bond holdings, leading to a further rise of foreign funding costs. This also opens the door to mutual risk migration between banks and sovereign. When the sovereign's creditworthiness exogenously improves, this boosts bank balance sheets, which in turn increases the sovereign's repayment incentives endogenously. Similarly, if bank balance sheets exogenously deteriorate, sovereign repayment incentives take a hit, which drives bank net worth down another notch through marking-to-market of its sovereign bond portfolio.

In practice, this makes the incentives in bank recapitalization stronger, since it makes repayment more beneficial for the government: Since government bonds are of no value in autarky (since domestic households are simply paying back themselves through lump-sum taxes), they can be used to attract foreign financing at cheaper rates when access is preserved.

All this would suggest that large domestic bond holdings are actually a positive for the effectiveness of bank recapitalization. There are two important qualifications to this insight: First, just as domestic bond holdings can strengthen government repayment incentives through a 'virtuous cycle,' this can generate substantial costs when the government overextends herself with an excessively large recapitalization. This suggests that in economies with large domestically held debt stocks, even more caution may be warranted in not overstepping the appropriate recapitalization size. Second, exogenous shocks, either to public or private balance sheets, become systemic and self-reinforcing through banks' sovereign bond holdings, and their effect increases with the share of the bank balance sheet that is taken up by domestic bonds.

4.2 Private sector risk sharing

The model can be extended further to analyze the impact of the recent innovation to the liabilities side of bank balance sheets. Following the bank bailouts of the Great Financial Crisis, European banking regulators have pushed banks to increase loss-absorbing capacity. A popular tool here has been the issuance of contingent convertible (CoCo) bonds, or the proposed Equity Recourse Notes (ERN) [5]. These bonds promise to provide banks with additional equity buffers in bad states without diluting current equity holders at the time of issuance. Most commonly, these hybrid securities are structured with a trigger level based on the ratio of equity capital to risk-weighted assets. Once this ratio falls below a pre-specified level, CoCo bonds automatically convert into common equity, or in some cases are even written down partially or completely. Furthermore, even before the trigger level is reached, coupon payments on CoCo bonds can be discontinued without the need to make up for foregone payments later. ERNs, as proposed by Bulow and Klemperer (2015) operate in a similar vein but promise to simplify the intricate conversion process that has bedeviled the current CoCo bond structure.

The CoCo (or ERN) mechanism provides banks with an additional, automatic source of capital or borrowing relief when capital levels are low and equity capital raising is difficult, explaining its popularity with regulators. Research such as Avdjiev et al. (2015) has shown that CoCo issuance has indeed served to reduce banks' credit risk. Interestingly, while corporate CoCo bonds had first been suggested in the early 1990s following the wave of junk bond issuance, [6] the European debt crisis brought with it calls for CoCo sovereign bonds, such as in Brooke (2013) or Hachondo et al. (2016), in order to reduce the risk of sovereign defaults.

However, the model at hand shows that integrating private risk sharing mechanisms into the

[5] Thank you to Andy Lo for this reference.

[6] *Distress-Contingent Convertible Bonds: A Proposed Solution to the Excess Debt Problem,* Harvard Law Review, Vol. 104, No. 8 (Jun., 1991), pp. 1857-1877

bank balance sheet alone already serves to reduce sovereign default risk, without having to extend CoCo funding to the sovereign directly. I add CoCo bonds to the model in the shape of ERNs as follows: Banks' international borrowing is assumed to consist of regular funding and a fixed percentage share of ERN funding. Instead of behaving like regular bonds, ERN bondholders are only paid the gross return on capital instead of the pre-determined gross borrowing rate if - without this alteration - bank net worth were to fall below a pre-determined trigger level. Bank net worth with CoCo financing in period 1 is then

$$n_1^{coco} = n_1 + (R_1^* - R_1^k) s^{coco} d^* \cdot \mathbb{I}_{n_1 < \bar{n}^{coco}}, \tag{24}$$

i.e. the normally computed net worth plus a 'rebate' of the bank funding cost in excess of the actual earnings on capital, scaled by the share of CoCo financing, denoted s^{coco}, if the normally computed net worth would fall below the trigger level $\bar{n}^{coco}$.

This leads to a reshuffling of the distribution of possible bank net worth levels in period 1. In the case of technology outcomes being normally distributed, the altered distribution of n_1 now has a much thinner left tail, and a bunching just above the net worth trigger level (Figure 4).

This change in the distribution of possible bank net worth outcomes has direct implications for the probability of default. If the CoCo trigger level is set appropriately, CoCo financing can drastically reduce the chances that bad technology outcomes produce large enough losses on bank balance sheets to make sovereign default optimal. This is especially noticeable when initial bank net worth is low relative to the trigger. In those circumstances, this also reduces the amount of optimal government recapitalization, while increasing the probability of repayment nonetheless. Since foreign lenders carry some of the risk of bad technology outcomes at some pre-determined capital level, higher recapitalization levels - which make it less likely that this level is hit - will reduce the value of this risk-sharing mechanism to the government (Figure 5).

5 Policy implications

Clearly, the model presented here is highly stylized and, by construction, omits a number of factors that matter in the assessment of policy, especially as it pertains to bank recapitalization (such as moral hazard, or bank run risk during financial panics). Still, the model allows to make some conjectures about optimal policy and also provides a framework to think about current policy issues and regulation.

First, the main insight provided here is that, at least for a small open economy in a currency union, there exists an optimal amount for bank recapitalization, and under- as well as overshooting this amount can be very costly. Exceeding this level, as arguably was the case in Ireland during the Great Financial Crisis, can be especially dangerous even when government finances are generally in order, and can induce a 'doom loop' of mutual contagion between the banking system and the sovereign.

Second, the model allows for a simplified discussion of recent ECB policy and compare them to the effects a banking union might have. Beginning with the OMT announcement in 2012, the ECB responded to the escalation of sovereign default risk in the Euro area with policy action directed at capping sovereign borrowing rates across the Euro area. More recently, the ECB's quantitative easing policies have been explicitly targeted at lowering sovereign rates, as policy makers have recognized that sovereign risk premia in the worst-hit economies have hampered the transmission of monetary policy.

Lower sovereign rates show up in the model at hand in two ways - once directly as a component that lowers the tax burden on domestic households, and as a boost to bank balance sheets by revaluing current domestic sovereign bond holdings. This combination has led to a dramatic reduction in private funding rates in the most vulnerable Euro area countries since 2012, as visible in the bank credit spreads computed by Gilchrist and Mojon (2014) and shown in Figure 6.

But while the sovereign rates of Italy and Spain have continued to decline in tandem up until recently(figure 7), bank credit spreads in the two countries begun to decouple in 2015[7]. In the framework of the model, this suggests that bank capitalization in Italy is lower than in Spain, even after the net worth gains from the revaluation of sovereign bond holdings are factored in. Italy's banks do in fact have a substantial problem with nonperforming loans, and recapitalization has been proposed and enacted in a few high-profile cases already, such as Monte de Paschi in late 2016 and the Veneto banks in 2017. However, there has been resistance to these moves in other Euro area member states, and the model at hand can provide some indication why: Since the sovereign rate had been practically capped by ECB policy, there were no market 'checks' on the scale of the fund transfer. Under the assumption that the ECB would continue to cap sovereign rates, Italy would be

[7] The graph shows aggregate interest rates as calculated in Gilchrist-Mojon. Since this measure includes the full maturity structure of bank debt, this is not comparable directly in levels with the sovereign 10-year yields in figure 7.

incentivized to funnel more money into its banks than would be optimal under normal conditions, where overshooting the optimal amount of recapitalization would impose costs on the sovereign. Instead, these costs are now carried (to some extent) by the ECB, since its current holdings of Italian government bonds would have fundamentally lost value even as market prices had stayed constant through the recapitalization process.

While this "socialization" of losses has produced some complaints from other European countries, it is important to note that this is in essence how a Euro area banking union would work (although importantly, the decision making on recapitalization amounts and loss sharing would importantly now lay with a supra-national regulatior). A banking union would allow for bank recapitalization in an individual country without forcing it to raise additional funds individually. As such, the negative effects from bank recapitalization (and the danger of 'doom loops') would be avoided, potentially creating large cost savings for the countries involved. Finally, at least in this model, individual bank recapitalization when sovereign rates are capped, such as in the current Italian situation, arguably amounts to a banking union through the back door.

Finally, third, what can the model tell us about current reform proposals? Most current discussions of Euro area reform center either on the need for more fiscal (i.e. public) risk sharing and governance improvements, or on the role of market forces and private risk sharing. A recent joint proposal of French and German academics (Bnassy-Qur et al. 2018) provides a thorough discussion of both viewpoints and a long list of beneficial policy changes in order to both prevent the risk of future crises as well as setting up mechanisms to mitigate the fall-out. I will discuss a few of their suggestions within the realm of the model here.

The main insight from this paper is that sovereign debt carrying capacity is directly linked to the health of the financial system through the sovereign's incentive to preserve access to international financing for the domestic private sector. This premise makes the model at hand better-suited to discuss a popular suggestion, for example by Brunnermeier et al. (2017), to lower the concentration of sovereign debt on domestic bank balance sheets. Since the 'doom loop' transmission of sovereign risk to banks is assumed to work through banks' bond holdings, this seems like a sensible improvement. But what would the impact on sovereign default risk be? That depends crucially on the model that we have for the sovereign default decision.

Even under the assumption that the total demand for each country's sovereign bond would not change (i.e. bonds would simply be reallocated across all of the Euro area's banks) and the amount of freely defaultable (external) debt was unchanged as well, default risk may go up. In other models of sovereign default that rely on default costs arising from intermediation disturbance (such as Perez, 2015, or Balke, 2017), sovereign default risk rises, since the potential hit from sovereign default to domestic intermediation will be smaller with more diversified banks. Here, the model presented here aligns better with what one might expect to see in practice. Under the assumption that default costs result from private sector exclusion, sovereign default incentives will not change, and the reduced domestic concentration of sovereign bonds will only result in a lower feedback effect from exogenous changes in sovereign default risk. This improved resilience can however be substantial, depending on the shock, and hence makes the policy seem reasonable, at least in terms of mitigating the costs of a crisis. The same message holds for introducting a 'Euro safe asset' - while useful in reducing a second-order contagion between public and private sector, it would help less in reducing ex ante sovereign risk, which is driven by outstanding sovereign debt levels.

How would fiscal transfers or an actual functioning banking union work? As discussed above in the case of Italy, transfers from abroad to the government or the banking system will have similar effects on default incentives, albeit with different marginal benefits. When the initial shock is concentrated in the banking system, a common deposit insurance for the Euro area will do better than fiscal transfers, especially when those come with conditionality over government deficits. Conversely, a strong banking system will make outside fiscal support less necessary even when public debt rises.

This leads to the final insight from the underlying mechanism in this paper: Sovereign risk is best mitigated by lowering the fallout risk in the financial system. This appears to be most elegantly and safely done by increasing the amount of private risk-sharing in the system. Focusing on a reduction of tail outcomes for banks promises to pay the highest dividends in reducing sovereign risk at almost all debt levels. When private sector investors, ideally in a locationally-diversified manner, take part in taking losses, such as through CoCo bonds, or other forms of bail-ins, this can drastically reduce the amount of sovereign risk in the tails.

Finally, this suggests that while a broad range of reforms can improve safety and stability in the Euro area, the largest (and potentially politically uncontroversial) gains in reducing sovereign risk exposure can be had by reducing financial system risk that falls on the domestic economy. This can be achieved through explicit changes in the funding structure of banks but also through encouraging a broader, cross-border footprint of Euro area banks and deeper financial integration, which should lead to an implicit Euro area wide risk sharing mechanism based on private investment decisions rather than political negotiations.

6 Conclusion

In this paper, I present a model of the interaction between sovereign and private sector credit risk, where funding costs for the local economy and sovereign default incentives are closely intertwined. I show that weak balance sheets in the banking system can be contagious for sovereign default risk, even when the sovereign is relatively stable. The model incorporates banking system recapitalization, and points to the risk of excessively large transfers from public to private balance sheets - but also to the virtuous cycle appropriately-sized transfers can have. If done correctly, bank recapitalization may even pay for itself. In the sum, the model is able to match a number of different scenarios observed in the European sovereign debt crisis, where the close connection of sovereign and financial system loomed large.

I also analyze the role of domestic sovereign debt holdings, and find them to amplify this mechanism. The model further show how using CoCo bonds in funding the banking system can serve in reducing sovereing default risk, and reduce the need for government recapitalization funds. Finally, I discuss the model's relevance for present and future policy in the Euro area. The model allows for a simple way to think about recent ECB policy targeting sovereign yields, as well as the implications these policies might have for a 'back door banking union.' Looking towards future reforms, the model emphasizes the importance of financial integration and other means of private risk sharing across the Euro area in order to reduce sovereign default risk relative to fiscal risk sharing or other public rescue mechanisms.

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Figure 3-1: Probability of repayment with debt-financed recapitalization

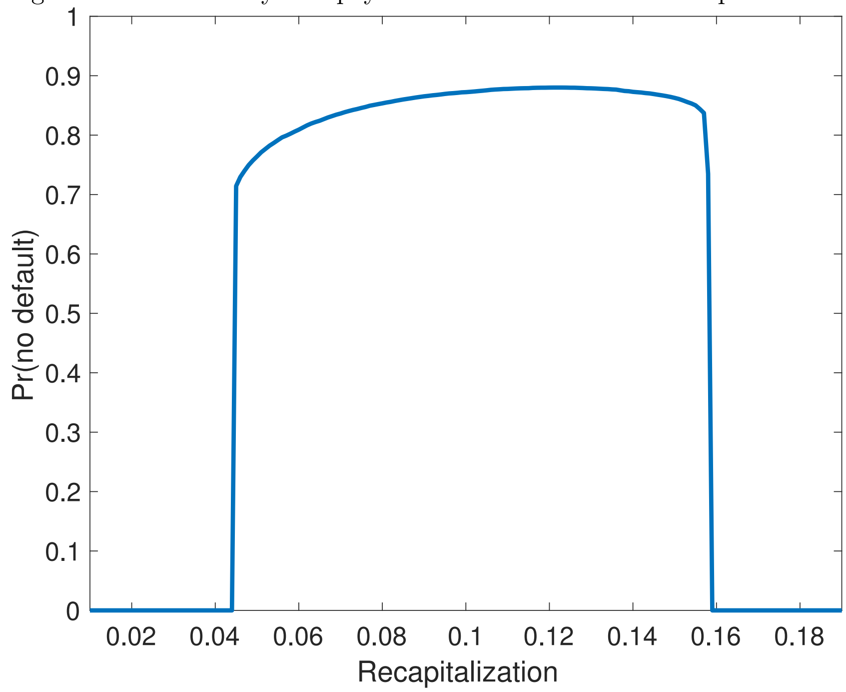


Figure 3-2: Behavior of truncated value functions

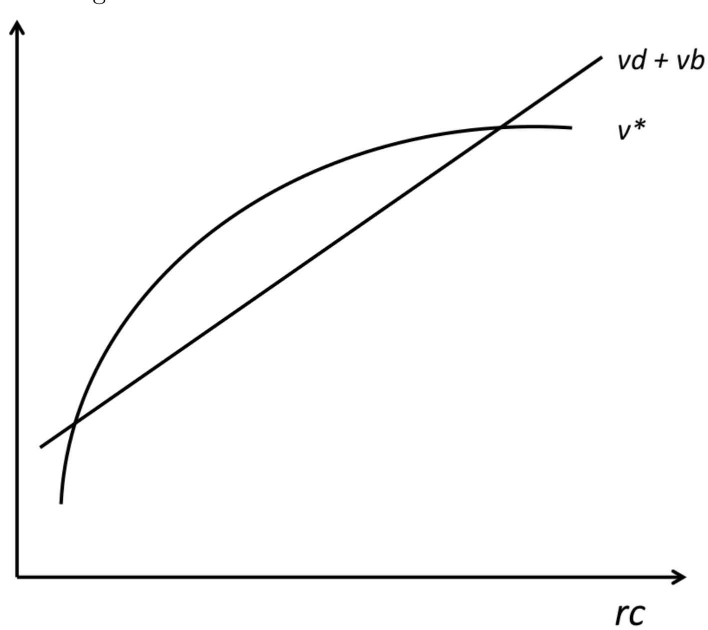


Figure 3-3: Probability of debt repayment with debt-financed recapitalization and domestic bond holdings

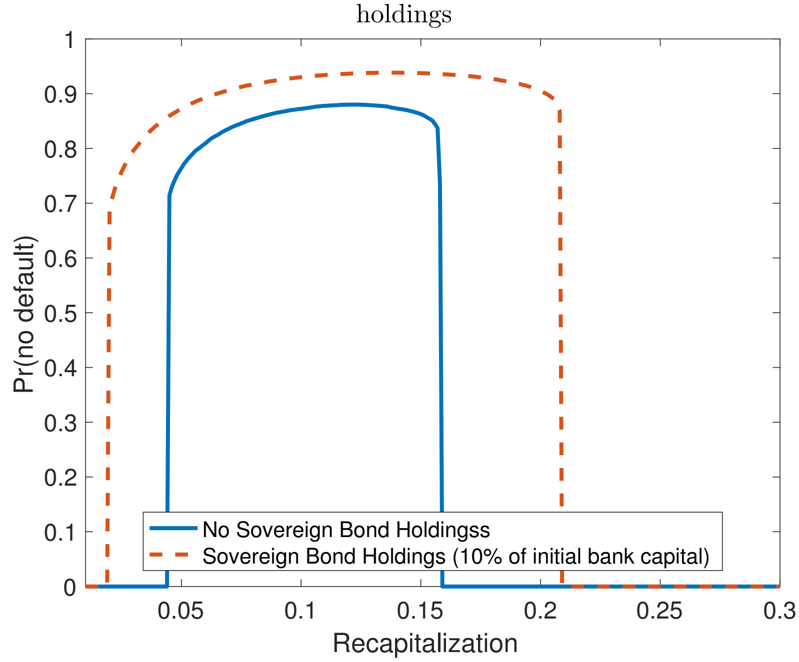


Figure 3-4: Distribution of n_1 realization with and without CoCo funding

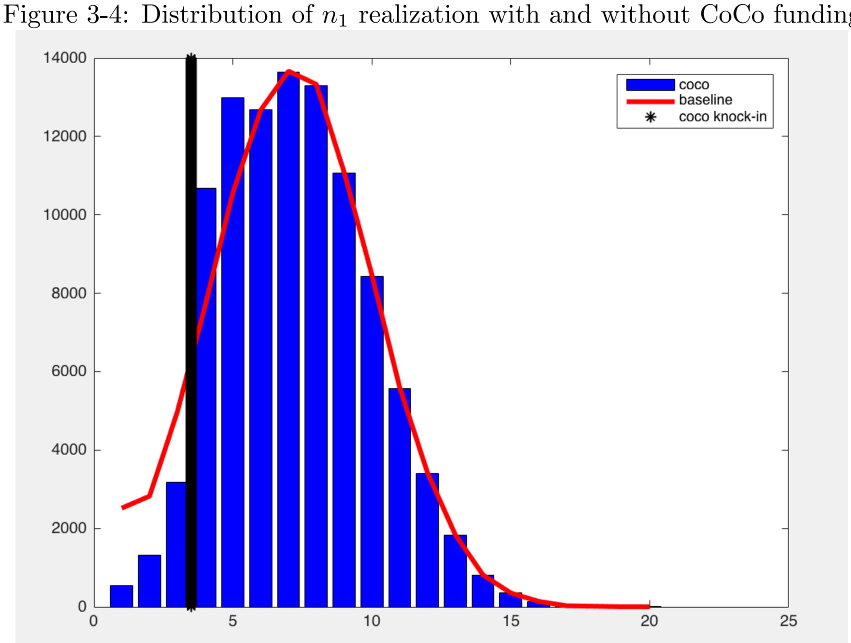


Figure 3-5: Optimal recapitalization with CoCo funding

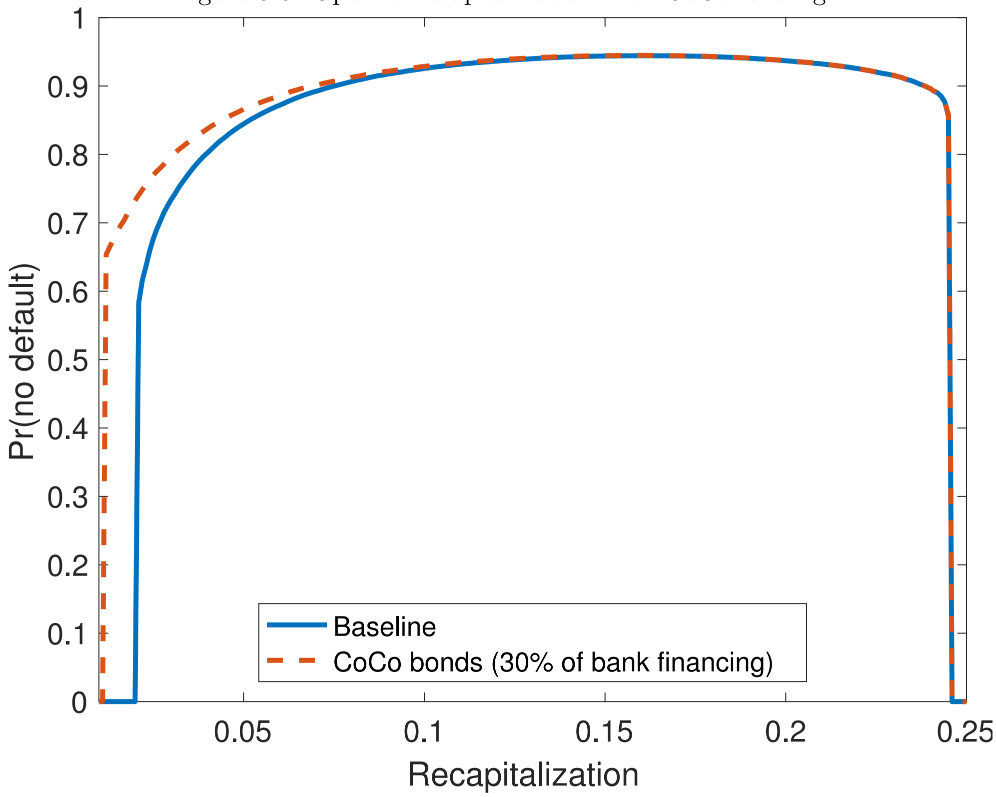
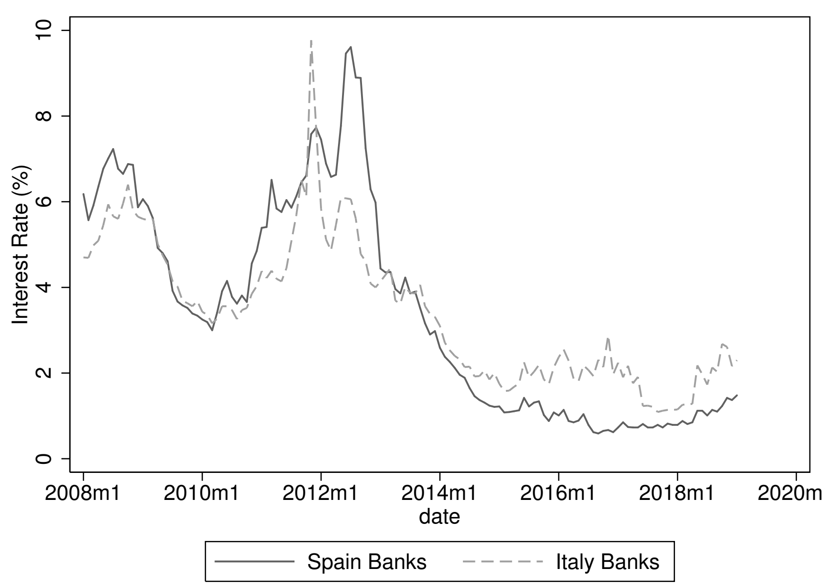
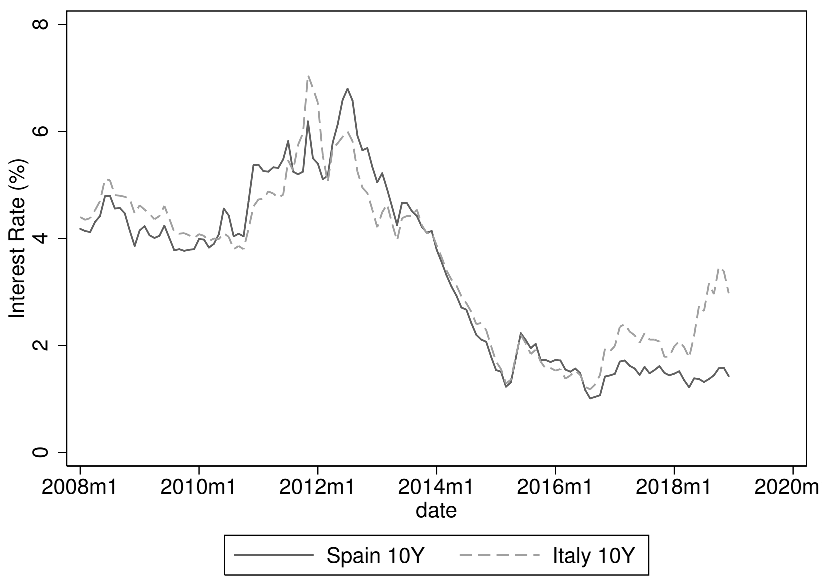


Figure 3-6: Banking sector borrowin rates



Source: Gilchrist and Mojon (2014)

Figure 3-7: Sovereign 10-year bond rates



Source: FRED

Appendix A Solution

In order to determine when default is optimal for the government, I first need to determine the different consumption streams in the default and the non-default case. I operate from the assumption that in period 1, banks choose foreign borrowing rather than domestic deposits.

A.1 Utility under default

I work backwards, starting in period 2. In this period, households get to consume their wages, their deposits from the previous period plus interest, as well as the left-over equity in the banks. Since in this case, there is no foreign funding for the banks, households receive the gross returns on all capital in the economy:

$$c_2^d = w_2^d + R_2^k k_2^d.$$

Furthermore, since banks have to rely on domestic deposits and pay the required funding costs, I can solve for the capital level in period 2 given default by setting equal the required net rate of return on domestic deposits with the marginal return on capital:

$$R_2 = \frac{1}{\beta} = R_2^{k^d} = \alpha A_2 (k_2^d)^{\alpha-1},$$

This yields period 2 capital level:

$$K_2^d = (\frac{1}{\alpha\beta A_2})^{\frac{1}{\alpha-1}}.$$

Since technology level A_2 is certain, the return on capital is deterministic and identical with the return on deposits. Rewriting c_2^d with the known capital stock k_2^d gives:

$$c_2^d = A_2 (K_2^d)^\alpha$$

Final household consumption for period 2 is hence pinned down by the known technology level and parameters of the model. However, the required capital stocks have to be raised solely from domestic deposits and bank net worth in the previous period. Given wages and bank capital, this pins down household consumption in period 1:

$$c_1^d = w_1 - (k_2^d - n_1)$$

Under assumption 2, I can aggregate households' total consumption stream in the non-default case, taking as given technology realization A_1, capital choice k_1, and bank initial net worth n_0, which includes the original recapitalization amount. The total utility for the household given government default is described by:

$$u(c_1^d, c_2^d) = w_1 - (k_2^d - n_1) + \beta(w_2^d + R_2^k k_2^d),$$

where both w_d^2 and R_2^k are determined by k_2^d, and hence are functions of model parameters.

A.2 Utility in absence of default

Again, I can solve backwards. Household consumption in period 2 in absence of default consists of wages and left-over bank equity. Domestic deposits from the previous periods are 0, since otherwise default would always be optimal. This yields:

$$c_2 = w_2 + (R_2^k - R_2^*)k_2 + R_2^* n_1.$$

Since there is no uncertainty in period 2, capital returns and borrowing costs are the equal to each other, so the equation reduces to:

$$c_2 = w_2 + R_2^* n_1,$$

where both wages as well as interest rate R_2^* are determined by the level of capital chosen by the banks. The bank sets equal the net cost of financing to the net marginal return on capital such that:

$$R_2^* = \chi[\frac{k_2}{n_1}]\frac{1}{\beta^*} = \alpha A_2 k_2^{\alpha-1}.$$

Therefore, I can solve explicitly for k_2 as a function of bank net worth n_1. As a result, household consumption at t=2 is also a deterministic function of n_1.

Moving on to period 1, in the case of no default and continued foreign borrowing, households consume everything that is not paid to the government as lump-sum tax to repay its short-term debt:

$$c_1 = w_1 - b^*$$

In aggregate, the total streams of consumption utility for households add up to:

$$u(c_1, c_2) = w_1 - b^* + \beta(w_2 + R_2^k n_1).$$

A.3 Default decision

As shown above, household utility in both the default and the non-default state are known with certainty in period 1, conditional on the amount of net worth in the banking system, n_1. This value only depends on past variables and the realization of technology A_1, which is known before the government has to decide whether or not to default. This makes the government's optimization problem in period 1 straightforward: It will pick the scenario under which household utility is highest. Hence, for the government not to default in period 1, the following inequality - taking n_1 as given - needs to hold:

$$u(c_1, c_2) \geq u(c_1^d, c_2^d).$$

Plugging in from above, this yields:

$$w_1 - b^* + \beta(w_2 + R_2^k n_1) \geq w_1 - (k_2^d - n_1) + \beta(w_2^d + R_2^{k,d} k_2^d)$$

This simplifies to:

$$\beta[(w_2 - w_2^d) + (R_2^k - R_2^{k,d}) \cdot n_1] \geq b^* - (1 - \beta R_2^{k,d})(k_2^d - n_1).$$

Since the return on capital in period 2 in default is necessarily the inverse of the household discount factor, this further simplifies to the no-default condition:

$$\beta[(w_2 - w_2^d) + (R_2^k - R_2^{k,d}) \cdot n_1] \geq b^*,$$

i.e., the government defaults as long as the discounted difference in capital and labor returns in period 2 in the non-default state relative to the default state is not enough to compensate households for the repayment of foreign debt in period 1. Importantly, while wages increase with higher levels of capital that can be achieved through foreign borrowing, capital returns fall. Hence, the increase in labor income from higher capital levels does not only have to be enough to repay government debt, but also to make up for the decreased return on bank capital n_1. Further, the cost of capital in absence of default is again determined by the amount of bank capital, since it directly enters the financing cost. Finally, bank net worth is a function of technology outcome A_1. Therefore, under the assumption that external borrowing is optimal for banks at time 0, bank capital in period 1 is derived as follows:

$$n_1 = R_1^k k_1 - R_1^* d_0^* = (R_1^k - R_1^*)k_1 + R_1^* n_0.$$

As visible above, the banking system is carrying technology risk on its books: While the capital return R_1^k is dependent on the realized technology state, R_1^*, the funding rate, is agreed-upon before the resolution of uncertainty, and is therefore based on $\mathbb{E}(A_1)$. In period 0, banks set equal their cost of financing to the expected return, such that:

$$R_1^* = \chi[\frac{k_1}{n_0}]\frac{1}{\beta^*} = \mathbb{E}(R_1^k) = \alpha\mathbb{E}(A_1)k_1^{\alpha-1}.$$

This means that in a bad outcome, bank net worth is eroded, which lowers the value of having access to international capital markets going forward. To clarify, I can rewrite the above no-default condition as follows:

$$\beta((1-\alpha)A_2(k_2^\alpha - (k_2^d)^\alpha) + \alpha A_2(k_2^{\alpha-1} - (k_2^d)^{\alpha-1}) \cdot n_1) \geq b^*,$$

where k_2^d is defined as in section 4.1, and independent of period 1 values, but where k_2 is directly dependent on the value of n_1 (as in 4.2), and hence the realized technology state. Subsequently, for a given n_0, I can solve the condition to find the level of required debt repayment b^* for all possible values of A_1, at which the government is indifferent between defaulting and not defaulting.

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